ANNUAL REPORT FY12
Habitat Assessment Funded Research

Project Title:Accounting for habitat-dependent observation error in bottom trawl survey indices for pelagic stocks using butterfish (*Peprilus triacanthus*) as a model

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Goals:
The objective of this project is to develop a method to use dynamic habitat models for pelagic fish to correct survey based abundance indices used in stock assessments for habitat dependent observation error. To maximize the likelihood our approach can be operationalized in an assessment context we have assembled and are collaborating within a broad, interdisciplinary inter-institutional working group of government, academic and fishing industry experts. This working group includes habitat ecologists, fisherman, oceanographers, stock assessment and ecosystem scientists as well as experts in cooperative research. We consider the activities of the working group an essential component of the project. It is organized to create an open, collaborative process for the development of science required for stock and ecosystem assessment among stakeholders with ecological expertise. We hope this process will enable us to deliver products in time to be considered in the next butterfish stock assessment scheduled for December 2013 by the mid Atlantic Fisheries Management Council.

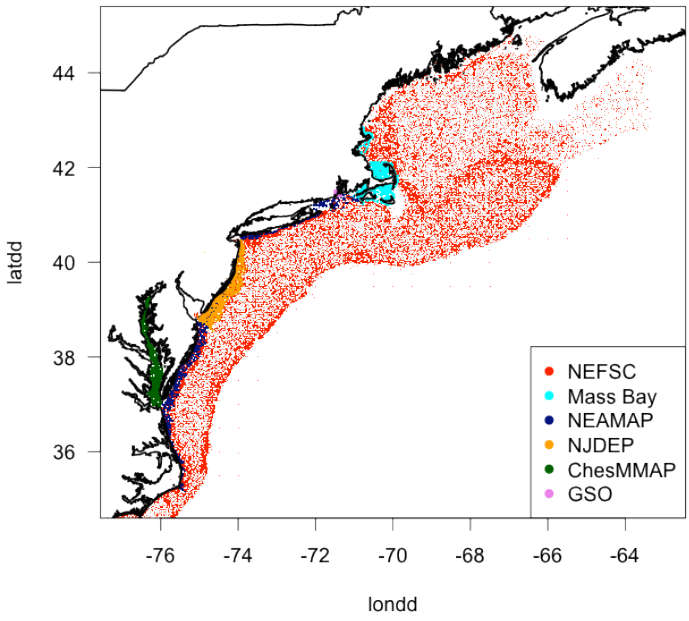

Figure 1. Map showing surveys requested and acquired which we are considering in analysis and modeling of dynamic thermal habitat for Atlantic butterfish. Two additional surveys which we have not yet received will also be included in our analysis.

Approach:
Goal 1: Butterfish are a small, short-lived pelagic fish, common on the eastern continental shelf of the US. The stock in the Mid-Atlantic Region is currently assessed using indices of

abundance derived from bottom trawl surveys conducted in continental shelf waters > 20 meters deep during September and October by the Northeast Fisheries Science Center (NEFSC). Abundance indices are calculated based on the assumption that population size is directly proportional to concentrations of animals measured in a surveyed habitat volume that does not change over time. Survey abundance indices are therefore assumed to accurately and directly reflect population trends and can be rescaled to estimate population size. We believe the habitat stability assumption is fundamentally flawed in the sea because habitat volumes are primarily defined by dynamic properties and processes of the ocean fluid and are therefor not stable over time, particularly for pelagic ectothermic organisms. This hypothesis is consistent with other studies (e.g. (Brodziak and Mountain, 2002; Prince, et al., 2010)). We believe concentrations of animals measured in fisheries independent surveys need to be standardized based on habitat volumes sampled and habitat volume available in regional ecosystems if indices are to accurately reflect population trends. Stock assessment surveys do not sample the entire habitat space organisms use at any life stage. For example, butterfish are common in deeper areas on the eastern US continental shelf sampled by federal surveys. However adults, as well as juveniles, also use the nearshore coastal zone and downstream reaches of estuaries < 20 meters deep as summer feeding and nursery habitats. These areas are not sampled in federal surveys currently used in recent stock assessments. One of our working hypotheses is that changing climate has resulted in a greater frequency of warm autumns in which the fall migration of butterfish from the shallow coastal habitats to the outer continental shelf has been delayed. Since the federal survey occurs offshore during a fixed period in September and October, delays in the offshore migration could result in systematic decreases in the amount of butterfish habitat sampled in the assessment surveys. Differences in mean CPUE resulting from changes in the proportion of available habitat and thus the population sampled in the survey could be misinterpreted a change in regional population size.

Our approach is to develop dynamic habitat models that can be hindcast to estimate the habitat available in the ecosystem and the proportion of habitat sampled on seasonal bottom trawl surveys. We propose to use these model based estimates of habitat available in the ecosystem and the proportion habitat surveyed to account for observation errors associated with habitat dynamics in the calculation of abundance indices. We will then compare the index accounting for habitat dependent observation error with those calculated using the traditional approach to determine whether our method produces assessments that better reflect retrospective trends and reduce uncertainty.

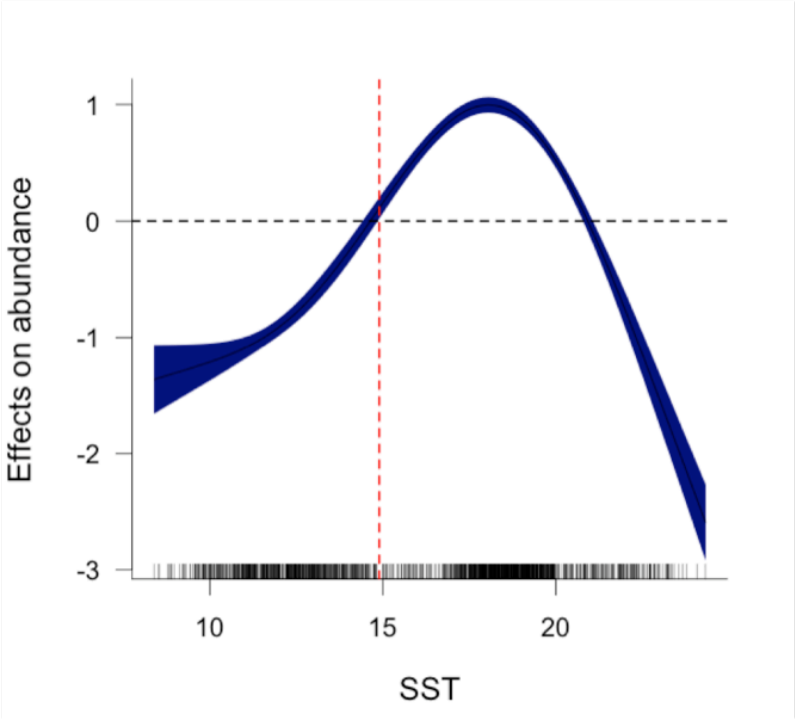

Figure 2. Generalized additive model describing changes in the abundance of butterfish and seas surface temperature measured in the nearshore NEAMAP survey in the autumn. We selected 15^{0}C as the threshold the index to apply to each pixel in the OISST data to determine the approximate day of the year in the fall when temperatures became "unsuitable" for butterfish in the nearshore.

Goal 2: To increase the likelihood our products have the accuracy and precision required for operationalization in stock assessment and management, we assembled a diverse interdisciplinary, inter-institutional working group of experts to serve as collaborators, advisors and reviewers. Invitees included government and academic stock assessment scientists including those who participated in previous assessments of the target stock. Since our method relies on oceanographic model hindcasting we invited experts in empirical and numerical oceanography from outside and inside NOAA. In addition to academically trained ecologists we have included 3 commercial fisherman with long histories in the small mesh trawl fishery and expert in the ecology of the target species. These fisherman represent ports of Point Judith, Rhode Island, Montauk, New York and Cape May New Jersey which are central to the small mesh trawl fishery in the Mid-Atlantic Region. We view the guidance provided fisherman essential to the ecological niche modeling and habitat hindcasting tasks since their knowledge is based upon practical ecological expertise that can only be gained by time on the water. Finally invited an ecosystem scientist as well as several experts in cooperative research and public outreach to join the group.

Work Completed:

Goal 1: *Develop a method to use dynamic habitat models for pelagic fish to correct survey based abundance indices used in stock assessments for habitat dependent observation error.*

1) Acquire fishery and oceanographic data

We have made requests for butterfish and hydrographic data from all of the large scale bottom trawl surveys conducted in near shore and offshore waters from Cape Hattaras to the Gulf of Maine (Table 1; Figure 1). Most of these datasets have already been acquired and we are processing and modeling them. We have also acquired the ¼ degree OOI Sea Surface Temperature data set http://www.ncdc.noaa.gov/thredds/ncss/grid/OISST-V2-

AVHRR_agg/dataset.html which describes daily sea surface temperatures for the Northwest Atlantic from 1981 to the present.

2) Have autumn temperatures changed in the coastal zone. Could these changes have delayed the offshore migration of butterfish from shallow (< 20 m) to deeper waters and potentially confounded survey based estimates of population size with changes in seasonal habitat dynamics?:

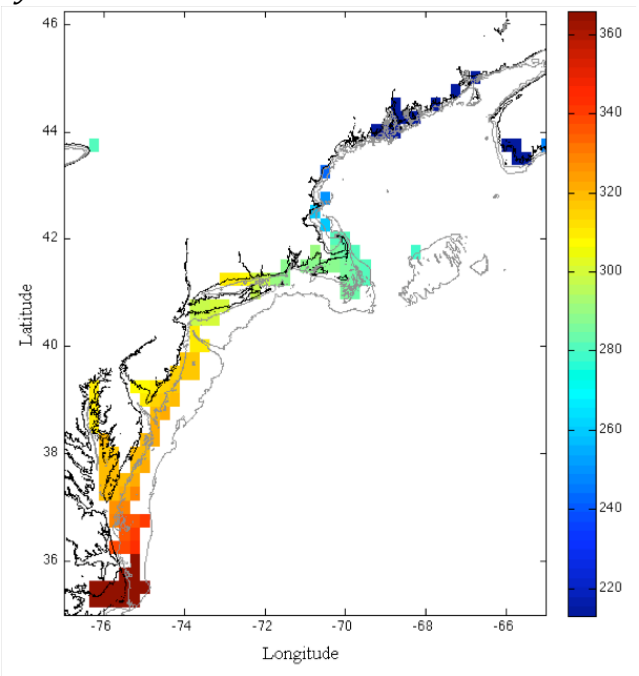

Figure 3. Days of the year in the fall (August 1- December 31) in 2001 when seasurface temperatures in the OISST dataset fell below 15C, the value at which thermal habitat in the nearshore becomes suboptimal for butterfish based on GAM (Fig 2).

The objectives of this portion of the project are to identify whether or not thermal triggers for fall offshore migration may have changed in the nearshore coastal zone of the north west Atlantic. Furthermore, we are examining abundance indices derived from inshore and offshore surveys to determine if there is evidence for delayed offshore migration. The work described in this task was completed in part by an intern funded through the CINAR program.

We have applied generalized additive modeling (GAM) to data collected in the North East Area Monitoring and Assessment Program (NEAMAP: see table 1) surveys to develop a preliminary index of thermal habitat "preference" with respect to fall sea surface temperatures for butterfish (Figure 2). This preliminary model indicates that butterfish become less abundant in the nearshore areas when sea-surface temperatures fall below 15C. Based upon this analysis we selected 15C as the value to apply to SST data to index days of the year when temperatures fell below values "preferred" by butterfish.

We applied this thermal index to NOAA 1/4^{o} resolution optimum interpolation sea surface temperature (OISST) data that provides daily SST estimates for the northwest Atlantic Mid-Atlantic Bight from 1981-2011. In this dataset, bias in satellite based estimates of SST are identified and corrected using in situ buoy and ship data (Reynolds et. al., 2002; Reynolds et al., 2007). To focus our analysis on the shallow near shore coastal zone during the fall, we created a subset of this satellite data that included pixels over bottom depths < 30m for days of the year between August 1 to December 31. Pixels over offshore banks shallower than 30m were filled with NA's in order to focus analyses on the coastal zone.

We then applied a running mean to temperatures in each pixel to determine the day of the year at which surface temperatures fell below the thermal threshold of 15C. We tested the sensitivity of this approach using 2, 5, 10, 15, and 20 day windows for calculating

means. We used a 5 day moving window in the analysis since this was the shortest period at which values stabilized. Using this approach we produced gridded maps of the day of each year in the fall when the thermal threshold of 15C was reached (Figure 3). This allowed us to analyze trends in the timing of Fall as indexed by butterfish thermal habitat preferences for each pixel from Cape Hattaras to the Gulf of Maine.

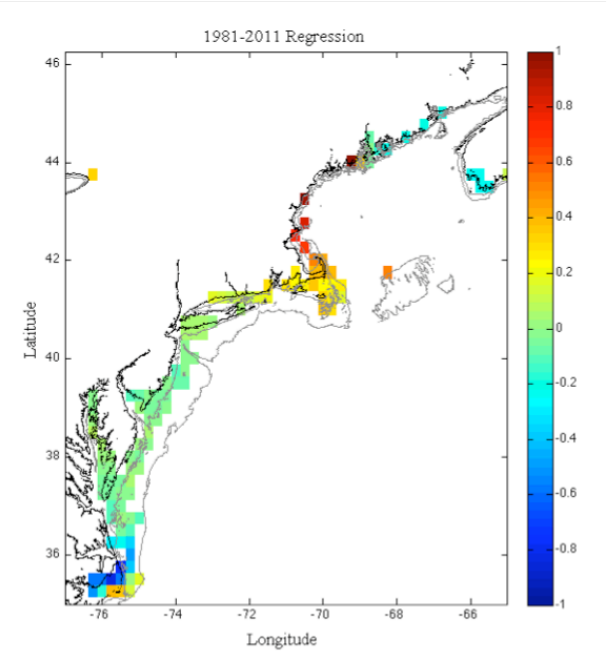

Figure 4. Linear rates of change (days/year) in day of the year in the fall when temperatures fell below the thermal threshold for preferred habitat for butterfish from 1981-2010. Rates were positive from the Hudson Shelf Valley to the southern part of the gulf of Maine Coastal Zone with "thermal fall" occurring later by approximately ½ a day per year in Block island and Vineyard sounds

Our analysis indicates that linear trends in the day of the year at which the 15C threshold was reached varied in space (Figure 4). Trends were positive in nearshore pixels northeast of the Hudson shelf valley and into the southern Gulf of Maine. These positive trends were highest in Block Island sound and averaging approximately ½ a day per year since 1980. This preliminary analysis indicates that thermal trigger for fall offshore migration for butterfish in southern New England may have advanced by more than 15 days over the past 30 years. Examination of pixels within four estuaries along the coast indicates that these phenological trends may not be entirely linear (Figure 5).

We are also beginning to analyze trends in the abundance of butterfish in fisheries independent surveys of near shore coastal areas and the continental shelf currently available to us (Figure 6). Several of these surveys appear to show increases in butterfish abundance in the near shore during the Autumn in the late 1900s through the late 2000 when NEFSC offshore survey indices indicated the stock was declining. However there is substantial variability in the trends among these nearshore surveys.

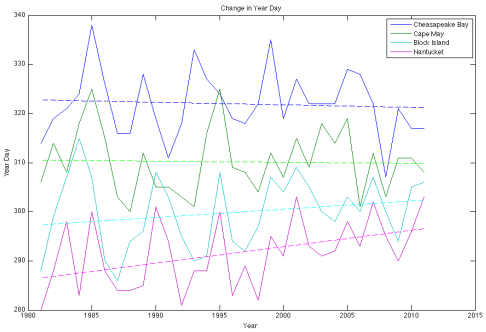

Figure 5. Time series of days of the year in the fall when temperatures fell below the 15C temperature threshold for four pixels in the OISST dataset located near Chesapeake Bay, Cape May New Jersey, Block Island, and Nantucket. Lines show linear trend lines showing slope over time. Rates were positive for pixels in Block island and Vineyard sounds

Next steps:

a) We will expand our modeling to identify a temperature threshold for fall egress of butterfish from the nearshore to consider all fishery independent surveys conducted in inshore waters during the autumn (Table 1).

b) We will reapply this threshold to the OI SST data to recalculate dates at which threshold is reached in each nearshore pixel and year.

c) We will use time series clustering to identify areas where trends in the phenology of

autumn temperatures relevant to butterfish are similar. We will also explore methods to identify nonlinear changes phenology that may have occurred

e) We will analyze the full suite of near shore and offshore surveys to determine whether or not the data support the delayed migration hypothesis and whether is a latitudinal gradient in the delay if there is evidence for a delay.

f) We will draft a white paper describing these results for consideration of the 2013 stock assessment (Due by May)

g) We will draft a manuscript for the peer review literature

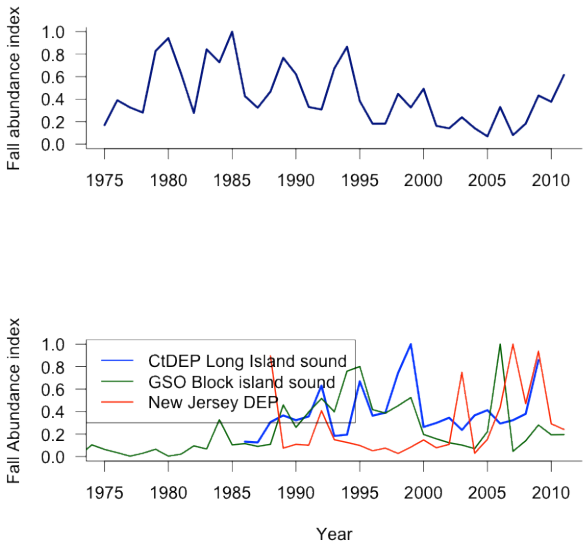

Figure 6. Time series of butterfish abundance measured during the fall on the continental shelf by the NEFSC (top panel) and 3 nearshore surveys (bottom panel).

3) Development of regional scale niche models

Our previous efforts to model butterfish habitat using NEFSC data indicated that a parsimonious model of animals response to bottom temperature produces an accurate first order approximation of the spatial dynamics of butterfish habitat at a regional sea spatial scale with a spatial grain of approximately 40 kilometers. This is consistent with scientific understanding of the importance of temperature in determining the vital rates of ectothermic organisms in the sea (Allen and Gillooly, 2007; Freitas, et al., 2010 and others). It is also consistent with observations made by work group collaborators participating in the small mesh trawl fishery. The work described in this task was completed in part by an intern funded through the CINAR program.

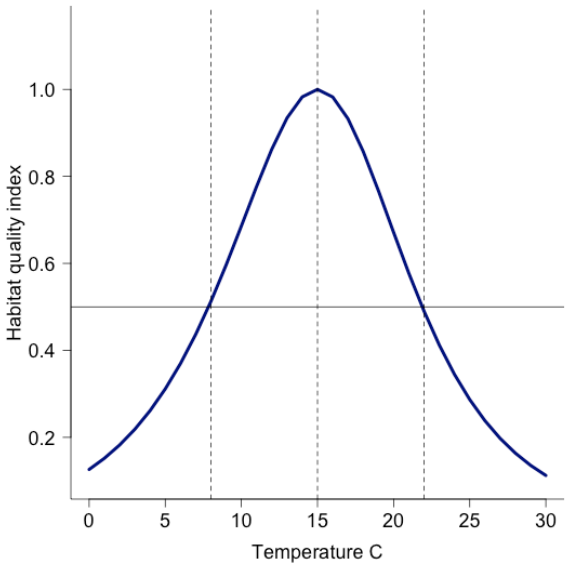

Figure 7. Preliminary Boltzmann-Arrhenius function parameterized on the basis of analysis of NEFSC offshore and NEAMAP onshore survey data for butterfish. Model predictions were rescaled to a maximum in-order to create a thermal habitat quality index ranging from 0-1. This function has a strong mechanistic basis in enzyme kinetics

Ongoing analysis of nearhore and offshore survey data available to us indicates that a thermal niche model developed using NEFSC data alone is "too cold" and a more general model capturing the organism response at the scale of the ecosystem needs to integrate information from nearshore as well as offshore surveys. We are developing analyses and code to do this data integration and modeling using two approaches. We are using a non-parametric statistical and fully empirical approach (GAM) to characterize the temperature response and estimate uncertainties. We are also developing an approach to use maximum likelihood estimation and/or Bayesian analyses to estimate parameters and parameter uncertainties for a parametric Boltzmann-Arrhenius temperature function (BA model) using animal densities as the response variate (Dell, et al., 2011; Johnson and Lewin, 1946; Ratkowsky, et al., 2005; Figure 7). This function rests on the foundation of chemical reaction kinetics and has thermodynamic terms that account for the temperature dependent inactivation of enzymes that limit metabolic rates. The Boltzmann-Arrhenius function has been used in analyses of a variety of physiological and ecological traits including population densities and population level growth rates (Dell, et al., 2011). We have produced several preliminary thermal niche models using both approaches and the data available to us. We are using these preliminary models to develop methods to evaluate the niche models. These methods include out of sample cross validation using the survey and environmental data used to parameterize the models as well as catch and temperature data collected by

members of the fishing industry involved in the NEFSC cooperative research program. We are also developing methods to examine residuals spatial variation in projected niche models with respect to catch and insitu temperature data collected on the NEFSC stock assessment surveys. Plots of spatial residuals show higher than predicted catches primarily associated with features such as Norfolk and Hudson Canyons and the shelf north of Atlantis and Veatch canyons that are traditionally rich fishing grounds for squid and butterfish (Figure 8). There are also areas of the outer shelf where our thermal niche model over-predicts butterfish abundance. This is to be expected since prey production, the presence of predators and availability of predation refuge are critical habitat features not included in our thermal habitat model.

The preliminary models have also been used to build an approach to spatially explicit habitat hindcasting and adjustment of survey based abundance indices.

Next steps:

a) We will complete data processing required for integration of nearshore surveys and offshore surveys by December 1.
b) We will complete coding for analyses, GAM modeling and out of sample cross validation of GAMs as well as parameter estimation for the Boltzmann-Arrhenius function by December 1.
c) We develop final thermal habitat models and estimate uncertainties in parameter values using the full suit of surveys by December 24.
d) We will schedule for January 2013 presentations describing the results of niche model along with steps 4 & 5 below to the working group as well as the NEFSC population dynamics branch. Adjustments will be made to the niche models model based on these reviews .

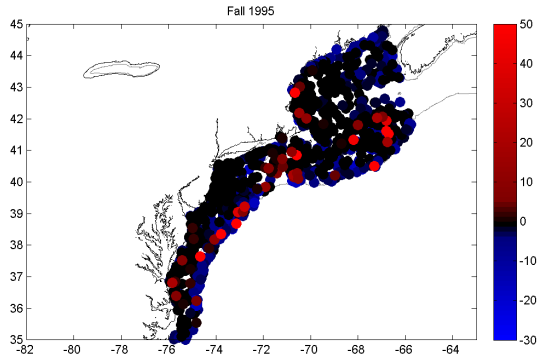

Figure 8. Spatial residuals from Generalized Additive Model describing butterfish abundance response to bottom water temperature made using NEFSC offshore survey date for Fall of 1995. Positive and negative residuals are concentrated along the shelf break and some areas that are traditional fishing grounds have strong positive residuals. These patterns may be driven by process controlling prey production and predation rates that are not included in thermal habitat models

e) We will draft a white paper describing our methods for building thermal niche models that can be operationalized in a management context that will be submitted for consideration in the 2013 butterfish stock assessment (Due by May, 2013). Included in this white paper will be annotated coding used in the approach

f) We will draft a manuscript for the peer review literature describing steps toward the development of the operational thermal niche model

4) Evaluation of regional scale hindcasts of bottom temperature for the northwest Atlantic from oceanographic models.

Since empirical measurements of

bottom water temperatures are not available throughout the Northwest Atlantic for projecting our thermal niche models at the spatial and temporal extents and grains required, we proposed to validate and use bottom temperatures hindcasts from oceanographic models. We are currently performing validation of three oceanographic models available to us; NYHOPs, HOPS, and ROMS, using bottom temperatures measured on NEFSC surveys, fishing boats participating in the NEFSC cooperative research program and other sources.

5) Projection of thermal niche model using hindcasts of bottom water temperature for the northwest Atlantic from oceanographic models.

We have coupled preliminary GAM and BA thermal niche models to a simulation of the Regional Ocean Modeling System (ROMS) (Shchepetkin & McWilliams, 2003, 2005) originally implemented to study variations in the Gulf Stream (Figure 8). This simulation, run by Enrique Curchitser (Rutgers), used a grid with a horizontal spacing of 7 km (720 x 360 grid points) and 40 vertical terrain-following levels. The bottom bathymetry is derived from the 1 min resolution Shuttle Radar Topography Mission (SRTM) database (Farr et al., 2007), and reanalysis data of Simple Ocean Data Assimilation (SODA) (Carton & Giese, 2008) version 2.1.6 are used for initial and oceanic boundary conditions. Ten major tidal components extracted from the TPXO dataset (Egbert & Erofeeva, 2002) were included in the model. Surface forcing, including sea surface temperature, humidity, pressure, wind, solar radiation and river runoff, are extracted from the Coordinated Ocean-ice Reference Experiments (CORE) datasets (Large & Yeager, 2009). The simulation uses was a 50-year (1958-2007) hindcast with model outputs averaged and daily. For the purposes of coupling the model output to our habitat models we only considered the bottom temperature output, but the simulation also provided ocean currents and various other features. The ROMS used in our preliminary projections is included among models evaluated in task 4.

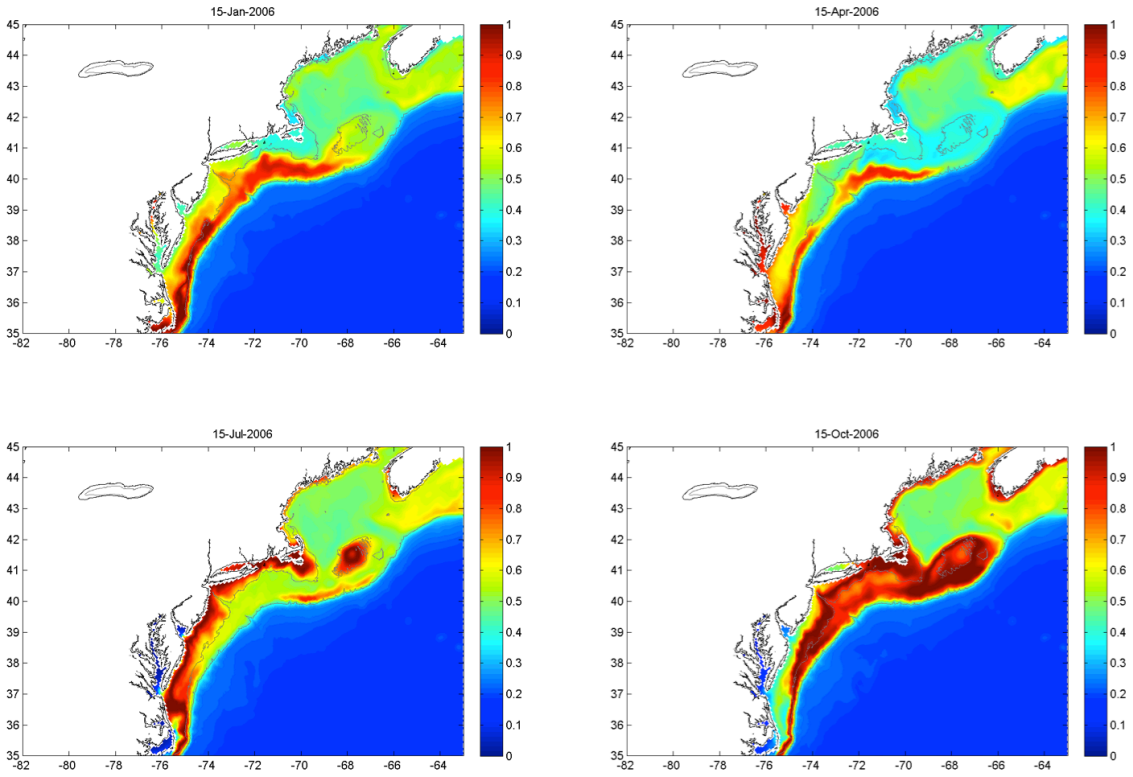

Figure 9. Snapshots taken from a simulation of butterfish thermal habitat quality made by coupling the preliminary Boltzmann-Arrhenius function (Figure 7) to ROMS hindcasts of daily bottom temperature in the northwest Atlantic from 1957 – 2007. Our intent is to use a refined version of this approach to quantify the amount of habitat sampled and habitat available during stock assessment surveys

The projections of the preliminary niche model (see Figure 9 and http://www.st.nmfs.noaa.gov/ecosystems/habitat/funding/projects/fy2012-projects) indicate that seasonal variation and interannual variation in the location as well as surface area of thermal habitat for butterfish may be substantial. Substantial changes in the timing of the seasonal habitat cycle may also occur (Figure 10). The NEFSC fishery independent stock assessment surveys occur at approximately the same time (September-October) and follow the same trajectory each fall. The survey generally begins on outer shelf south of the Hudson shelf valley to Hattaras, North Carolina. Then it proceeds North and East inshore and mid-shelf from the Mid-Atlantic Bight into the Gulf of Maine. We have projected surveys onto thermal habitat simulations and are have begun to evaluate proportions of potential thermal habitat for butterfish available each year that fall within survey strata and are sampled on the surveys.

Next steps:

a) We will use the preliminary simulation and the NEFSC survey strata to develop the approach to estimate the proportion of thermal habitat within and outside the NEFSC survey strata in each year. Specifically we will estimate interannual variation in the proportion of butterfish thermal habitat falling within inshore strata

(1-92) and offshore strata (1-14, 16, 19, 20, 23, 25, and 61-76) that were used to estimate abundance in the last assessment (SARC 49).

b) We will rerun simulation using thermal niche models developed by December 1
c) We will use uncertainties estimated for niche models and oceanographic model hindcasts to estimate uncertainties in thermal habitat projections
d) We will evaluate the accuracy of our thermal habitat projections through consultation with fishing industry collaborators.
e) We will use approaches developed using preliminary models to recalculate annual estimates of the proportion of thermal habitat falling within and outside the NEFSC survey in each year.
f) Results will be presented to the working group and the NEFSC population dynamics branch in January 2013.
g) The results will be included in the draft white paper for the 2013 assessment
h) The results will be included in the draft manuscript for the peer review literature.

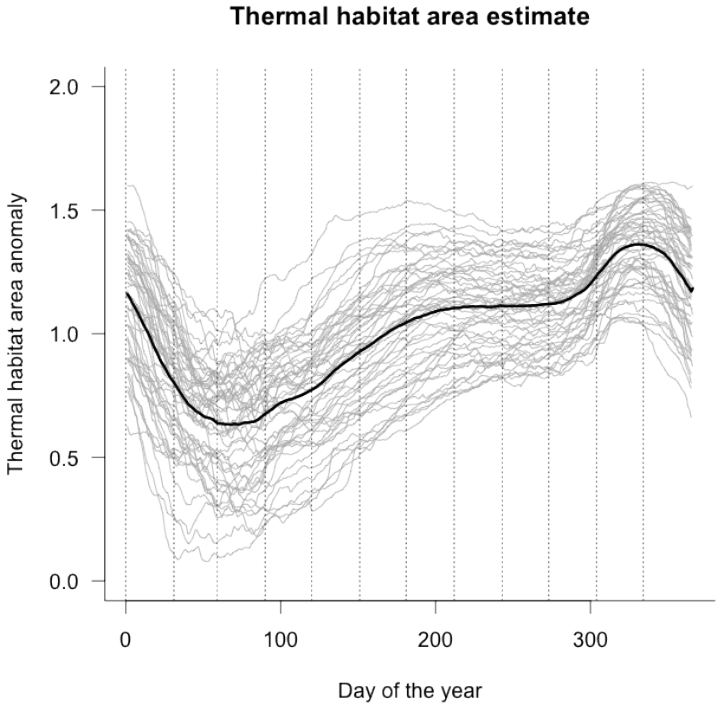

Figure 10. Changes in thermal habitat area estimated using simulation of the Boltzmann-Arrhenius function for butterfish thermal habitat quality (preliminary) coupled to ROMS bottom temperature hindcasts from 1957 to 2007. Area was quantified by classifying pixels with thermal habitat quality greater than 0.5 as habitat (see figure 7). Grey lines indicate yearly trajectory of habitat area. Black line is the mean trajectory. The anomaly was calculated as a ratio of the grand mean of habitat area. Thus values of 0.5 indicate that habitat surface areas were 50% smaller than the mean while values of 1.5 are 50% larger than the mean.

6) Adjustments to indices of population abundance based upon thermal habitat surveyed and thermal habitat available.

In order to understand the impacts of conducting a standard survey on dynamic habitat, simulations are required which generate 1) representative standard fisheries surveys, 2) population distributions with defined statistical properties, and 3) both idealized and realistic sampling areas within which to distribute a spatially structured and dynamic population. The end product of this effort will be a set of software tailored to the NEFSC surveys and the mid-Atlantic Bight region, but initial efforts are taking the shape of a review of existing methodology from various fields, code development, and idealized test cases. We expect to move toward more realistic arenas and locally appropriate population distributions shortly.

To date, we've conducted a review of survey simulation approaches used by various laboratories (e.g., USGS Pawtuxet Lab (Pearse, Royle, etc.), Animal Movement (Garton et al.); WiSP (Zucchini et al.) and have run test cases using some of these methods. We've generated a number of different population distributions in an idealized arena and have implemented some simplistic survey schemes. These methods are now being ported to the bathymetric maps used in the habitat modeling component of the project.

Next steps – We're attempting to construct a flexible software package in either matlab, fortran, or java that will allow for the exploration of survey properties across idealized to realistic arenas. Some challenges remain with respect to the assumed 'true' distribution of the organisms, their behaviors with respect to movement patterns and gear avoidance (diel migrations). The project is considering the use of acoustic data and net sampling from the commercial industry to address these challenges. Once we have the software in fairly robust shape and understand more about the interaction of dynamic habitat with a habitat-ignorant mobile survey under controlled conditions (fixed population sizes and with known distributional assumptions), we'll begin a retrospective analysis of past surveys using modeled habitat dynamics.

Goal 2: Development of a diverse interdisciplinary, inter-institutional working group of experts to serve as collaborators, advisors and reviewers. We taken the following steps within this goal:

1) In May 2012 we invited ecologists, oceanographers, stock assessment scientists from government and academia as well as fishing industry experts to a project scoping meeting in June (Table 2). Our aim was to invite a diversity of experts who could best help develop and evaluate an advanced approach to meet our operational goal and who were familiar with the stock assessment process and thus able to help maximize the likelihood our products might be considered in assessment. Finally we made sure that invitees were not just experts in their respective fields but also represented the diversity of interests in applied science and management in the mid-Atlantic Region.

2) In June 2012 we held the 1 day scoping meeting with members of the workgroup at Rutgers University. The agenda (Table 3) included reviews of the 2009 stock assessment for butterfish, methods to incorporate environmental data into stock assessment, recent habitat modeling efforts with butterfish and preliminary evidence that climate driven changes in seasonal habitat dynamics may be producing systematic observation errors in indices of stock abundance. The group then discussed alternative approaches that could be used to bring habitat to bear in the next assessment as well as ecosystem issues that should be considered in the medium and longer term (Appendix 1).

3) In early October 2012 we reached out to working group members with a status memo describing our progress over the summer months much of which was based on frameworks developed during the scoping meeting (Appendix 2)

4) Our focus now is on the development and evaluation of an accurate set of thermal niche models and the validation of bottom temperature hindcasts from oceanographic models that will be used to project those niche models. We hope to achieve this by January 1 2013. The Co-PIs are continually reaching out to individual workgroup members who can provide expert advice on methods for building these essential building blocks for our approach. These individuals (see table 2) include Chris Roebuck, Howard Townsend, Peter Morin and Andre Schmidt. We have also been consulting continuously with work group members expert in cooperative research and outreach including Greg Didomenico, Peter Moore, and John Hoey.

Next steps:

a) We intend to schedule a Workgroup Meeting to review the thermal niche models, as well as habitat projections and estimates of available habitat sample in the NEFSC surveys in January 2013. We will also review strategies to apply these analysis to account for habitat dependent observation errors.
b) We will call on specific workgroup members with expertise in stock assessment to help us to develop these strategies. Work group members who are representatives of the fishery will be kept informed about the strategies and our progress.
c) Indices of abundance that account for habitat dependent observation error and those calculated using traditional approach will be used in assessment models and the results compared with respect to precision and the accuracy with which they match retrospective patterns. The results will be reviewed by the working group. We will attempt to make this happen before June 1 2013.

Brief Summary of How Funds Were Used:
The funding was used:

1) For travel and incidentals associated with a workgroup scoping meeting in June 2012
2) Travel for Manderson to attend and present approach at the World Fisheries Conference in Edinburg Scotland in May
3) Travel for Manderson to attend and present project approach at the "International Symposium of the American Institute of Fishery Research Biologists on "The Relative Importance of Fishing and the Environment in the Regulation of Fish Population Abundance." June 26-28 2012, New Bedford MA
4) Software for Quinlan to perform simulation modeling of habitat model projections and fisheries independent stock assessment surveys in order to evaluate possible methods for quantifying habitat dependent observation error and adjusting indices of population abundance.
5) Books on statistical approaches to habitat modeling that could be used in the project
6) A deep water CTD probe that could be used in a collaborative field evaluation of the habitat model on a fishing vessel of opportunity
7) Note: Moneys transferred from NOAA through the CINAR program and to Rutgers and Stevens Institute Co-PIs has only just arrived (week of October 15, 2012).

Publications/Presentations/Webpages:
Manderson J.P. Kohut, J. Hoey, J., DiDomenico, G. 2012 "The butterfish smackdown": Steps towards the development of an operational seascape ecology in support of ecosystem co-management. World Fisheries Congress " Edinburgh Scotland 7th - 11th May 2012

Manderson et al "The butterfish smackdown": Steps towards the development of an operational seascape ecology in support of ecosystem co-management. Garden State Seafood Association Meeting, Tuckerton, NJ May 3, 2012

Manderson et al "Steps toward an operational seascape ecology in support of the management of sustainable ecosystems" for invited talk and book chapter for 2nd International Symposium of the American Institute of Fishery Research Biologists on "The Relative Importance of Fishing and the Environment in the Regulation of Fish Population Abundance." June 26-28 2012, New Bedford MA

Manderson (2012) Keynote Address: Does our habitat paradigm cross the land-sea boundary. Keynote talk at 2nd National Habitat Assessment Workshop, Seattle Washington Sept. 2012

J. Kohut, J. Manderson, J. Hoey, C. Roebuck, L. Palamara, M.J. Oliver, S. Gray, G. DiDomenico""Can we improve stock assessments by using dynamic habitat models and fishery-dependent surveys as a supplement to current fishery-independent surveys? ICES ANNUAL SCIENCE MEETING, BERGEN NORWAY. Sept 1012

Amelia Snow, John Manderson, Josh Kohut1, Laura Palamara 2012 EVALUATING CHANGES IN THE PHENOLOGY OF FALL IN THE NEARSHORE COASTAL ZONE USING A THERMAL HABITAT MODEL FOR A MARINE FISH. MidAtlantic Chapter of the American Fisheries Society Annual Science Meeting. Baltimore, MD

Kohut & Manderson 2012. Can we improve stock assessments by using dynamic habitat models and fishery dependent surveys as a supplement to current fishery surveys?. ICES CM-F_18. ICES Annual Science Conference, Norway.

Applications:
Under development as described above.

Literature Cited:

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Table 1) Trawl surveys requested and acquired to be considered in development of habitat models and empirical support for hypotheses.						
Survey Dataset	Acquired	Obs N	Stations N	Depths (50th, 5th, 95th quantile)	Area	Years considered
ChesMMAP	Y	3908	60	10.4 (4.88, 23.77)	Chesapeake Bay	2002-2012
Connecticut DEP (long Island Sound	R				Long Island Sound	1984-present
Delaware Bay	R				Delaware Bay	
Mass Bay, Division of fisheries	Y	6635	97	17(8, 58)	Buzzards Bay to ???	1978-present
NEAMAP	Y	1425	148	13 (7, 34)	Hattaras to Rhode Island sound	2007-present
NEFSC	Y	36452	365	66 (15, 237)	North west Atlantic coastal ocean	1970-present
New Jersey DEP	Y	4430	29	16 (7, 26)	New Jersey Coast	1988-present
URI GSO	Y	5275	2		Block Island Sound	1959-present
VIMS survey	R				Chesapeake Bay	

Table 2. Invitees and active members of the working group formed to develop an approach to account for observation error associated with dynamic habitat in the calculation of abundance indices used in stock assessments. It is hoped that we can maintain the group to further integrate ecosystem considerations into assessment.

Name	Institution	Expertise	Attended June 1 meet	Core &Active
Cadrin,Steve	SMAST, UMASS Dartmouth	Stock Assessment	N	
Didden,Jason	Mid Atlantic Fisheries Management Council	Stock Assessment	N	
Didomenico,Greg	Garden State Seafood Association	Fishing industry	Y	Y
Dobson,Collin	Rutgers University	CINAR Intern	Y	Y
Georgas,Nikitas	Stevens Institute	Ocean Modeling	Y	Y
Hare,Jon	North East Fisheries Science Center, NMFS	Oceanography, Marine Ecology	N	Y
Harris,Jim Jr	Independent	Fisherman Ecologist	N	
Hoey,John	North East Fisheries Science Center, NMFS	Cooperative Research	Y	Y
Jech,Mike	North East Fisheries Science Center, NMFS	Marine Ecology, Fisheries Hydroacoustics	Y	Y
Jensen,Olaf	Rutgers University	Stock Assessment	Y	Y
Kohut,Josh	Rutgers University	Oceanography	Y	Y
Lachener,Hank	Independent	Fisherman Ecologist	N	
Latour,Rob	Virginia Institute of Marine Science, MAFMC SSC	Stock Assessment	Y	Y
Lee,John	Independent - The Dented Bucket	Blogger	N	
Manderson,John	North East Fisheries Science Center, NMFS	Habitat Ecology	Y	Y
Miller,Tim	North East Fisheries Science Center, NMFS	Stock Assessment	Y	Y
Moore,Peter	MARACOOS Mid Atlantic Regional Association Coastal Ocean Observation System	Public Outreach	Y	Y
Morin,Peter	Rutgers University	Ecology, theoretical & empirical	Y	
Palamara,Laura	Rutgers University	Ecological & Ocean Modeling (Tech)	Y	Y
Quinlan,John	South East Fisheries Science Center, NMFS	Oceanography, Marine Ecology, Ecosystem & Stock Assessment	Y	Y
Richardson,Dave	North East Fisheries Science Center, NMFS	Oceanography, Marine Ecology, Habitat in Stock assessment	Y	Y
Roebuck,Chris	Independent	Fisherman Ecologist	N	Y
Schmidt,Andre	SMAST, UMASS Dartmouth	Physical Oceanography, Modeling	Y	Y
Seagraves,Rich	Mid Atlantic Fisheries Management Council	Ecosystem Assessment	Y	Y
Snow,Amelia	Rutgers University	CINAR Intern	Y	Y
Townsend,Howard	North East Fisheries Science Center, NMFS	Ecosystem Modelling	Y	Y

Table 3. Agenda for June 16, 2012 Butterfish working group scoping meeting		
Time	Agenda for Workgroup meeting in Lipman Hall, Rutgers Cook College campus	Discussion leads
9:00	Brief introduction to HAIP project to incorporating habitat considerations into butterfish assessment model	Manderson
9:10	Deadlines relevant to butterfish assessment and the working group	Latour
9:20	Review of stock assessment process in general	Miller, Jenson
9:40	Review of last butterfish assessment in particular	Miller, Jenson
10:20	Break	
10:30	Review of collaborative habitat modeling project & relevance to butterfish stock assessment	Kohut, Manderson,
11:20	General review of environmentally explicit stock assessment methods	Miller, Richardson, Quinlan
12:00	Discussion and decisions about issues WG will and will not address	Manderson
12:10	Working lunch: Data available for habitat modeling	Richardson
13:10	What sort of index does the habitat model need to produce for assessment model? With discussion of near-term goals and tasks	Miller, Jensen, Richardson, Quinlan
13:40	Alternative habitat modeling approaches supplying indices that can be integrated into assessment models. Followed by a discussion of near-term goals and tasks	Quinlan, Jech
14:55	Break	
15:10	Validation of HOPs Models, Oceanographic reanalysis of bottom temperatures & eventual integration into approach. With discussion of near-term goals and tasks	Georgas, Smidt, Kohut
15:35	Ecosystem & Socio-Economic considerations: eventual integration. With discussion of near-term goals and tasks	Townsend & Seagraves
16:00	Agreement on list of near term goals, deadlines and task assignments from afternoon discussion	Manderson
16:30	Adjourn	

APPENDIX 1. Manderson and Kohut notes from the June 16th scoping meeting to deve
method to integrate habitat considerations into butterfish assessment.

Priorities and next steps:

1) Collate basic life history information on the species—*Short term*
2) Work on climate change inshore autumn habitat hypothesis — *Short term*
3) Fine tune basic preliminary gam to apply to survey indices once Olaf Returns fr
Mongolia (residual approach)—*Short term*
4) Work on technique to merge data from different surveys and etc. to parameteri
temperature and solar elevation response (DRs Bucket technique) -- *Short term*
5) Work with PO modelers on method to back calculate total amount of butterfish
habitat sampled in each year

1. WORKSHOP NOTES:
1a. Important deadlines

Coastal Pelagic working group is in control of the assessment

Early December 2013: Butterfish assessment review meeting

Early November: All materials need to be delivered to reviewers 1 month in advance o
review

October 2013: Modeling meeting

Early July 2013: Data Meeting: Materials need to be completed for data meeting. This
particularly true we develop an alternative approach to use survey indices to estimate
population trend.

1b. On stock assessment & butterfish:
Benchmark assessments- Next assessment is a benchmark. December 2013

The future: Separate operational assessment and research tracks (this project is a
prototype research track)

CIE- center of independent experts review assessments—Independent reviewers cann
have received money from NOAA. As a result most are foreign.

Important for project to connect with the coastal pelagic working group. Paul Rago, Tir
Miller, Gary Sheppard are contacts

In next assessment: All strata with depths less than 20M are going to be dropped from
analysis of population trends due to depth limitations of Bigelow
APPENDIX 1 (continued)

**We need to understand which strata will be used from the Survey.

Assessment has two age classes: Age-0 & age 1+

State surveys are not directly input into assessment because there are no precision estimates for surveys. (Manderson?: What exactly is a precision estimate for these surveys. How is it calculated?)

*Many surveys are not included because of their limited coverage; differences between the methodologies add uncertainty to the regional assessment

Model used in previous assessment is KLAMZ model, a Delayed-difference model.

Very imprecise estimates of z=M+F

Age structure has changed, rarely see fish older than 2. Before there appeared to be older age classes.

The trend in population is down and age structure may or may not have changed. There is also very little Fishing mortality. So either M must have gone up or there is a habitat issue, IE larger proportion of the population could be using parts of the ecosystem that are not effectively sampled in surveys used in the assessment

Come up with covariate to explain downward trend in the survey data

Lots of discussion of design based vs. model based indices. The general consensus amongst SA scientists was that we should support a design-based approach, estimate indices based upon stratified random design. (If you turn the ocean on i.e. the temporal dynamic of the environment and consider trajectory of the survey its clear that the survey is not stratified random over time)

1c. Habitat modeling

Can reduce butterfish bottom habitat model to bottom temperature and solar elevation and retain explanatory power. A simple approach is defensible. Some discussion of moving beyond gams to a mechanistic approach. There is evidence that potential temperature triggers for fall migration offshore are trending later in the year.

1d. Time & environmentally explicit assessment

Short-term goals
Size dependent approach to standardizing the trawl survey indices in relation to environment

Medium term

Focus on habitat specific Mortality ==== Z=F+M and environmental effects.
APPENDIX 1 (continued)

Long Term
Integrate biotic interactions into a more holistic ecosystem based approach

1.e What should we focus on---
1) SHORT TERM: We want to reduce the uncertainty in the fall (spring?) survey indices.
- Include size structure/ontogeny (index for each size class)
- improve the precision of the indices
- Can we make the spring survey applicable to the assessment?
- Can we make the near shore surveys applicable to the assessment?
2) MEDIUM TERM: Does habitat influence natural and fishing mortality

3) LONG TERM: Explore joint model with squid and predators.

1f. Surveys (Richardson)*:*
Otoliths morphologies are different for inshore and offshore butterfish types.

Inshore surveys with butterfish
Maine-New Hampshire Survey
URI GSO survey -
Long Island Sound
NEAMAP

Several of these inshore surveys are showing increases in butterfish abundance in recent years

1g. Discussion between Olaf and Tim
Apply habitat model to survey data and use the difference of predicted to observed as your annual index of population trend. (Manderson?: perhaps I am being thick but this approach seems to give you the deviations in trends in abundance per "unit" habitat in the ecosystem. It assumes there is no relationship between habitat volume and population size. If there is a relationship between habitat and population size then these numbers need to be extrapolated out for the amount of habitat in the ecosystem when the survey occurred. The thinking in the residual approach may be that the environment affects only q, catchability, not concentrations of animals within available environmentally defined habitat which need to be converted into abundances for estimates of regional population trend. Under a climate change scenarios this is an important problem)

There was allot of discussion about reducing uncertainty and that this should be the focus of the group/project. There needs to be discussion of accuracy too

APPENDIX 1 (continued)

1h. On PO models
Nikitas and Andre to validate the HOPS to models for bottom water temperature using NOAA
ctd data and industry temperature data. Then they will begin to work out a method to do bottom

temperature reanalyses of temperatures throughout the ecosystem for the surveys… This will allow for an estimation of the total thermal habitat in the ecosystem.

This will allow us to estimate the proportion of thermal habitat actually sampled during the surveys

1i. Ecosystem approach*:*
Howard Towsend : focus on and try to combine habitat and analysis of diet to begin to investigate trophic interactions within habitat.

Rich Seagraves: Discussion of duke project on Socio-Economics.

Mid-Atlantic council is looking on how to transition to ecosystem management.

1) Interest for this project is the interaction of loligo and butterfish. Multi-species management

2) Impact of climate change on sustainable harvest of loligo and butterfish.

3) Consider predators to understand variability in natural mortality (top down)

4) Include prey species and physical forcing (bottom up)

5) End to end including economic model.
- Duke group is bringing in 3 students to work on the economic and ecological values. How do you quantify the ecological value? I.e. it is a food source for other species.
- How will the policy decisions of the council and quota's affect the coupled ecological-economic system?

6) Fatty acid analysis & diets

7) Refined estimates of predator/prey overlap
look at the other important interacting species in parallel.

2. SUMMARY OF IDENTIFIED NEXT STEPS:
Determine statistical modeling approach to address how much of the animal's habitat did the survey sample. Explore mechanistic approaches

APPENDIX 1 (continued)

GOAL: improving the relative abundance (by size) estimate within a given year.

Approach 1: Can we objectively determine inclusion or exclusion of strata to be used in the estimates of abundance trends?

Approach 2: Weight abundance based on temperature.

Approach 3: Apply habitat model at each tow location and time to get a difference between predicted vs. actual caught. Use the mean residual per tow as an index of abundance. (Does this assume environment only effects catchability not population size?)

Approach 4: Quantify the habitat 'outside' of the survey strata…In addition to amount sampled inside the survey area

3. ACTION ITEMS (Short Term):

1) Olaf and John run model indices of trend adjusted using a simple gam - August

2) Life history on butterfish (Manderson and Richardson)

This feeds the habitat modeling approach and an understanding of links between changes in climate and areas in the ecosystem animals are using during surveys.

3) Oceanographic model evaluation

4) There will be a term of reference for squid/butterfish predator prey interaction.

APPENDIX 2

WORKING DOCUMENT: BUTTERFISH WORKGROUP STATUS
October 4, 2012

Below are the steps we have taken since the June 12, 2012 Scoping Meeting followed by the next steps we believe will allow us to inform the butterfish assessment scheduled for December 2013.

To refresh memories the working group settled on the following goals

1) SHORT TERM: We want to increase the accuracy and reduce the uncertainty in the fall (spring?) survey indices.
- Include size structure/ontogeny (index for each size class)
- Improve the accuracy and precision of the indices
- Can we make the spring survey applicable to the assessment?
- Can we make the near shore surveys applicable to the assessment?

2) MEDIUM TERM: Does habitat influence natural and fishing mortality.

3) LONG TERM: Explore joint model with squid and predators.

Activities since the Scoping meeting

We have focused this summer on developing a draft plan for 1) habitat model development and hind-casting and 2) approaches to apply a habitat model in calculation of stock abundance based on the volume of habitat sampled in the surveys relative to the habitat available in the regional ecosystem. We have been experimenting with different approaches using preliminary habitat models that we are refining and validating this fall. We have also performed empirical analyses of potential long term changes in the thermal dynamics along the coast with special emphasis on areas that lie inshore of the NEFSC survey. These analyses indicate that higher quality thermal habitat appears to persist longer in the fall perhaps delaying migration into the survey areas in southern New England. This trend is not evident south of the Hudson shelf valley

Specifically we have:

1) Continued gathering survey data from inshore and offshore surveys for butterfish, (and longfin squid) and environmental variables. We have set October 1 as the deadline for collecting data for the final development of habitat models.

2) We continue to develop approaches to habitat modeling for butterfish using available data and empirical as well a mechanistic approaches.

3) We have performed a preliminary analysis of seasonal habitat dynamics estimated using a prototype mechanistic thermal habitat model for butterfish that we have coupled to daily ROMS model bottom temperature hindcasts from 1957 to 2007. We have been evaluating the implications of those dynamics in the light of the short, medium and long term priorities defined at the June scoping meeting.

APPENDIX 2 continued
4) Manderson, Kohut and Palamara worked closely this summer with 2 CINAR interns (Amelia Snow, Colin Dobson) who focused on specific facets of the short term priorities defined in the June WG meeting

Student project titles:
Snow, Amelia: Sea Surface Temperature as a Trigger of Butterfish Migration: A Study of Fall Phenology

Dobson, Colin: Combining Ocean Observing Systems with Statistical Analysis to Account for a Dynamic Habitat

The students presented posters at the CINAR review meeting in Woods Hole in August 2012. Both Amelia and Colin are continuing their work with us in the fall

Presentations:
Since the working group meeting we have given following presentations focused thermal habitat dynamics, population assessment and dynamics for butterfish

1) Manderson, Kohut, Hoey, DiDomenico (2012) "Steps toward an operational seascape ecology in support of the management of sustainable ecosystems" American Institute of Fishery Research Biologists on "The Relative Importance of Fishing and the Environment in the Regulation of Fish Population Abundance." June 26-28 2012, New Bedford MA

2) Manderson (2012) Keynote Address: Does our habitat paradigm cross the land-sea boundary. Keynote talk at 2nd National Habitat Assessment Workshop, Seattle Washington Sept. 2012

3) J. Kohut, J. Manderson, J. Hoey, C. Roebuck, L. Palamara, M.J. Oliver, S. Gray, G. DiDomenico (2012) Can we improve stock assessments by using dynamic habitat models and fishery-dependent surveys as a supplement to current fishery-independent surveys? ICES ANNUAL SCIENCE MEETING, BERGEN NORWAY. Sept. 2012

Proposals Submitted:
We have also submitted 2 proposals highly synergistic with the HAIP proposal.

1) An industry based survey for short-lived pelagic stocks stratified by thermal habitat
This proposes a field evaluation of the thermal habitat models combined with a model guided industry based assessment survey stratified in real time using habitat models. NOAA COOP program.

2) Thermal habitat dynamics in the Northwest Atlantic and the role of the winter habitat squeeze in density dependent regulation of forage species populations*.* This proposal is focused on the medium term goal outlined at the WG meeting in June. NOAA Fate Program.

Others steps:

APPENDIX 2 continued

1) John Quinlan & Dave Richardson have been working on methods to simulate dynamic habitat and surveys in order to evaluate mathematical and survey strategies to account for habitat dynamics in estimates of population size.

2) Manderson, Kohut, Palamara and the interns attended the Mid-Atlantic Fisheries Management Council Meeting in New York City in June

3) Manderson, Kohut, Palamara attended the Mid-Atlantic Fisheries Management Council SSC meeting in Baltimore in September.

Next Steps: Task list & Workflow:

1) Habitat Model Development and Validation:
    a) Acquire and do basic processing of trawl survey data by Oct. 15
        - NEFSC (complete)
- MASS BAY(complete)
        - URI data (complete)
        - NEAMAP - (complete)
- Long Island Sound ctDEP trawl (Data request in)
- New Jersey DFW trawl survey (Data request in)
    b) Build final empirical model using GAM/GLM approaches by Nov 1
        - Analyze size at age to get 0 and 1+ Classes (near completion).
        - Final analysis of bottom temperate and sun elevation for each survey dataset separately (Underway).
        - Identify methods to merge models based on individual survey datasets into a single model by Nov 15.
    c) Fit final mechanistic model by Nov 30.
        - Use results of combined empirical models as start values and priors for fitting mechanistic models to the abundance data.
    - Estimates of the parameters and associated uncertainties.
    - Out of sample evaluation using cross validation and independent catch and temperature datasets.
d) Evaluate ROMs Bottom Temperature hind casts by Nov 30
    - Assemble bottom temperature output from the hindcast.
    - Assemble concurrent bottom temperature from cooperative research group
    - Quantify the comparison between the two.
        - Seasonal and inter-annual.

2) Review Habitat model
    a) Meet with Pop Dynamics branch and present the model (December).
    b) Meet with the workgroup, in person or virtually (end of January).

c) Meet with industry (December-February, based on fishing schedule).
- Cape May

APPENDIX 2 continued

- Montauk
- Rhode Island

d) Make final corrections to habitat model by Jan 30.
e) Engage the coastal pelagic working group?

3) Bring Habitat model to bear in the development of indices of abundance working with the assessor (Tim miller??) and workgroup members on the SSC.
a) Evaluate possible approaches including (Deadline: March 2013)
- Purely habitat based. Population size = habitat specific CPUE x thermal habitat area
- Select strata based on habitat
- Select stations based on habitat model within strata
- Standard approach

b) Write up results by May 1

4) Preliminary ecosystem consideration
a) Perform the same habitat model development for squid
b) Diet data of squid and butterfish
c) How do we make links to Human ecology/economies more explicit?

5) Preliminary Paper Topics (attempted submission for all by June 2013)
a) Butterfish Fall Phenology - Lead: Amelia Snow
b) Evaluation - Lead: Steven Gray
c) Evaluation Fall - Lead: Manderson
d) ICES - Lead: Manderson
e) Thermal habitat dynamics of small pelagics of NW Atlantic: Lead: Palamara