AGRICULTURAL RESEARCH FOUNDATION
INTERIM REPORT
FUNDING CYCLE 2017 – 2019

TITLE: The future of Oregon's fisheries: Incorporating habitat quality and climate into albacore tuna production estimates

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EXECUTIVE SUMMARY: Juvenile North Pacific albacore tuna support an important fishery in the coastal waters of Oregon when they pass through the region during their annual migration in the spring and late fall. In contrast to other tuna fisheries around the world, the stock of albacore tuna in the North Pacific is believed to be healthy and the fishery is relatively sustainable. There is some evidence that patterns of climate variability (such as the El Niño Southern Oscillation) have impacts on habitat availability for albacore tuna. However, the impact of changing climate and current structure on habitat for albacore tuna is not fully understood because habitat quality for albacore tuna has yet to be quantitatively and mechanistically defined. We argue that habitat quality must be defined from the perspective of an individual species or life stage since the physiological and behavioral requirements differ across species and life stage. The main goal of this proposed research is to use growth rate potential (GRP), a quantitative measure of fish habitat quality and essential fish habitat based on bioenergetics models, to quantify habitat for albacore tuna in the coastal waters of the Pacific Northwest, and to examine changes in habitat due to manifestation or strengthening of stressors and climate conditions.

OBJECTIVES: We intend to: 1) develop a GRP model for albacore tuna habitat quality in the coastal waters of Northern California, Oregon, Washington, and Canada; 2) examine the impact of past climate shifts (e.g. El Niño events) on albacore tuna growth rate potential in this region, including shifts in essential fish habitat for the species; 3) develop a predictive framework to incorporate habitat quality in estimates of albacore tuna distribution and production, both short-term (1-3 years) and long-term (e.g. the year 2100); and 4) provide maps of albacore tuna habitat quality in the coastal waters of Northern California, Oregon, Washington, and Canada to local and regional fisheries managers.

PROCEDURES:

Water temperature, salinity, and dissolved oxygen data have already been obtained from over 37,000 CTD/XBT casts taken between 1929 and 2013 (NOAA's World Ocean Database; Fig. 1). Daily coastal upwelling indices (which relate to coastal hypoxia) will be obtained from the Pacific Fisheries Environmental Laboratory for 15 sites along the North American Pacific Coast, and monthly oscillation indices, such as the index that tracks El Niño

events, will be obtained from the National Weather Service Climate Prediction Center and the NOAA National Centers for Environmental Information.

GRP is a grid-based approach where the aquatic habitat is divided up into spatial cells (depth by location), and where each cell (defined on a volume) is characterized by a specific set of measured or modeled attributes such as water temperature, oxygen, and prey density (Brandt et al. 1992). The model uses environmental variables, as well as parameters describing a species' bioenergetics, to estimate GRP. The GRP general model has already been developed and has been tested previously on many species in the Chesapeake Bay and the Northern Gulf of Mexico by our research team.

We proposed to parameterize and validate a new GRP model for albacore tuna, using the available literature on albacore diet and metabolism (Edsall et al. 1974, Graham & Laurs 1982, Boggs 1991, Stewart & Ibarra 1991, Kirby et al. 2000, Kirby 2005, Blank et al. 2007). We will run the GRP model newly parameterized for albacore tuna on a daily basis for each spatial cell defined by the availability of environmental data. Annual GRP will be incorporated into age-structured population dynamics models for albacore tuna (e.g. Cox et al. 2002) to develop an annual index of abundance at the population level. These annual indices, as well as annual GRP, will be compared to historical catch data and fisheries-independent surveys when available. This information will provide a good baseline for comparison to validate modeled output.

We will use statistical models to develop future scenarios of habitat quality based on past conditions, and incorporate this information into age-structured population models to predict albacore tuna distribution and production. These models will be used to understand and forecast the effect of species-specific habitat quality on population dynamics of albacore tuna. Long-term forecasts will be used to look for tipping points and thresholds that may be generated by different scenarios. These tipping points will represent levels of ecosystem stress that will produce quick, extreme changes in tuna distribution or production, with consequences for the ecosystem and fisheries in the Northern Pacific.

All code for processing environmental data will be produced in R statistical software, and all data will be organized into a relational database in PostgreSQL, an open source database management system. These products will be made freely available to relevant fisheries management agencies (including ODFW and NOAA) via a web interface for follow up analyses and other collaborative efforts.

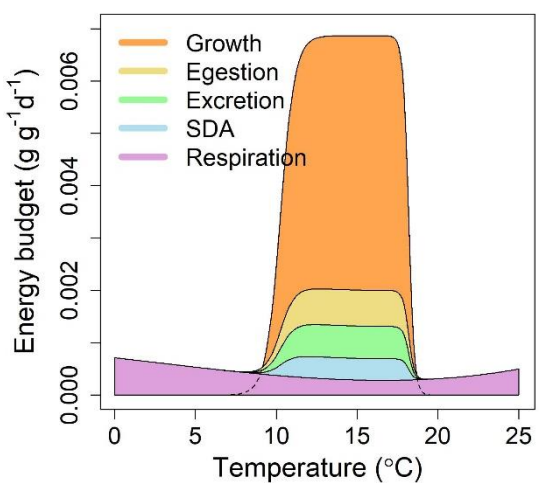

Figure 1. Bioenergetics model for albacore tuna.

SIGNIFICANT ACCOMPLISHMENTS TO DATE:

We have created a new spatially explicit, bioenergetics-based GRP model for albacore tuna using the available literature on albacore diet and metabolism (Edsall et al. 1974, Graham & Laurs 1982, Boggs 1991, Stewart & Ibarra 1991, Kirby et al. 2000, Kirby 2005, Blank et al. 2007). In this model, growth is confined to a very narrow band

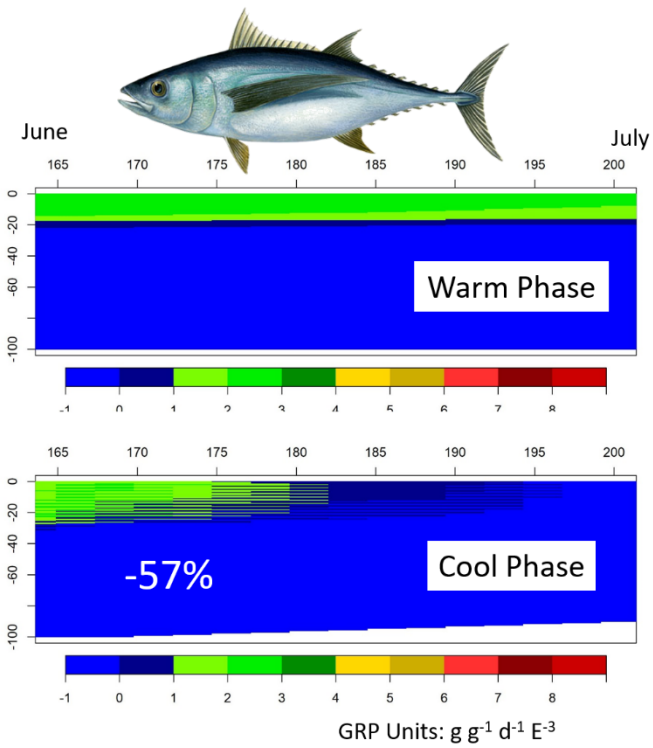

Figure 2. Albacore tuna growth rate potential (GRP) off the coast of Oregon during the months of June and July during a year characterized by a warm phase of the PDO (1985) and a cool phase of the PDO (2000).

of temperatures, from about 11-17 °C (Figure 1). In addition, costs due to respiration increase as temperature decreases to reflect partial endothermy.

We used CTD/XBT cast data and the albacore tuna GRP model to calculate the quality of pelagic habitat for the northern portion of the California Current, a highly variable region characterized by large scale climatic oscillations, including the Pacific Decadal Oscillation. In particular, we quantified water column habitat quality for a site off the coast of Oregon during the months of June and July during a year characterized by a warm phase of the PDO (1985) and a cool phase of the PDO (2000). Habitat quality for albacore decreased by 57% during the cool phase of the PDO, as compared to warm phase (Figure 2). These results were presented at the 2017 Ecological Society of America annual meeting in Portland, Oregon.

ADDITIONAL FUNDING RECEIVED DURING PROJECT TERM:

Beginning Researchers Scholarship Program, project title "Impacts of the environment on albacore tuna feeding and growth". PI: Stephen B. Brandt. Budget: $750.

FUTURE FUNDING POSSIBILITIES:

Submitted: NOAA Coastal Hypoxia Research Program, project title "Hypoxia off the Pacific Northwest Coast: Does it really matter to pelagic fishes and fisheries?" PI: Stephen B. Brandt with Cynthia Sellinger, Cassandra N. Glaspie and Brian Burke (NOAA). Budget: $268,917. Note this includes Albacore tuna.

Submitted: NOAA Living Marine Resources Cooperative Science Center, project title "Forecasting salmon habitat quality and returns based on short- and long-term oceanographic drivers". PIs: Stephen B. Brandt, Jessica Miller, Cassandra N. Glaspie, Cynthia Sellinger with Laurie Weitcamp (NOAA). Budget: $175,242.