ASPECTS OF HABITAT OF PARTICULAR CONCERN FOR FISH POPULATION DYNAMICS AND FISHERY MANAGEMENT

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SUBTHEME: Building habitat condition in the stock assessment process and fishery management strategies

BIO

John P. Manderson is a research fisheries biologist working for the North East Fisheries Science Center Cooperative Research Program NMFS, NOAA. His research interests include relationships between habitat dynamics, population and ecosystem dynamics; applications of Integrated Ocean Observing Systems to marine habitat and ecosystem ecology, and in developing quantitative seascape ecology supporting the assessment and management of regional marine ecosystems. His approaches include blending the ecological knowledge of academic and fishing industry experts into a holistic science that integrates "wild" and human ecological systems and supports strategies of sustainable natural resource use. Dr. Manderson received his PH'D in Natural Resource Conservation from the University of Massachusetts, Amherst.

Dr. Manderson is the founder and lead of the OpenOcean study group which recently engaged government, academic and fishing industry experts to develop of an environmentally explicit method to estimate the availability of fish populations to resource assessment surveys. The method the group developed was successfully applied in the 2014 assessment of Atlantic Butterfish. Dr. Manderson received his PhD in Natural Resource Conservation from the University of Massachusetts, Amherst.

ABSTRACT

Habitat ecologists charged with developing products useful for the assessment and management of marine populations and ecosystems face two competing challenges. To meet requirements of fisheries stock assessment, we are challenged to "trade space for time" and develop quantitative indicators of habitat effects on recruitment processes that can be integrated into models of population dynamics. These habitat indicators usually make spatial habitat characteristics implicit in order to develop time series of seasonal to inter-annual changes in ocean structure likely to affect important life history processes at the spatial extent of whole populations. In contrast, tactical ecosystem management, which currently emphasizes spatial management, requires that we "trade time for space" and

produce high resolution maps of habitat conditions that ultimately result in the successful completion of species life histories through reproduction. It is often expected that habitat conditions represented in these maps will be stable over long time scales that sometimes match those of human governance systems more closely than the ocean ecosystems they are designed to represent.

I attempt to identify which of these competing demands can be met operationally by habitat ecologists, right now, given the nature of ocean habitat and the data and analytical approaches available and accepted by fisheries stock assessment and management communities. In many regions, the development of habitat information for fisheries management is based on species-environment relationships statistically extracted from field surveys used in stock assessments. These analyses assume that dependent variables (presence-absence, abundance, body size, species diversity) vary directly with habitat suitability. Furthermore, the surveys; designed to develop precise estimates of mean population size at annual time scales; have sampling grains, lags and extents that are coarse in both space and time with respect many important species-habitat relationships in the sea. As a result statistical analyses of stock assessment survey data are most useful for describing dynamic species-habitat associations at scales of 10s of kilometers and 6 to 12 months. These associations are typically related to the geographic range and seasonal migration dynamics of populations. The analyses are therefore less useful for developing high resolution spatial maps required for tactical management than for integrating the potential impacts of habitat suitability at macro-ecological scales into stock assessments.

I present an example of a "macro-ecological" scale analysis and modeling of thermal habitat designed to inform population assessment. The analysis used a coupled thermal niche-ocean model to investigate the potential impacts of habitat dynamics on observations of population size as well as habitat availability on population demography for an important forage species, long fin inshore squid, on the northeast US continental shelf. Multi-model inference indicated that the statistical model with the strongest support included terms for habitat effects on demographic as well as the observation process. Spring population size increased with the quantity of thermal habitat available during the winter when the dominant demographic process affecting squid appears to be natural and fishing mortality. However, estimates of spring population size were also smaller when the proportion of thermal habitat sampled during the spring survey was small. Furthermore, the effect of habitat on the survey observation process was much stronger than habitat effects on demography. While the indicators of habitat surveyed and habitat available in the winter were not correlated, the results, nevertheless, suggest that there is a risk of confounding habitat effects on survey observation and demographic processes. Both types of habitat effects need to be explicitly taken into account to integrate ocean habitat dynamics into models of fish population dynamics in a manner that can improve the accuracy of assessments informing fisheries management.

It is becoming increasingly clear that the effects of ocean habitat dynamics on survey observations and on population demography are often not random but can show strong trends. Violations of the stationarity assumption of traditional stock assessment models have become more likely because of systematic, human induced, changes in the climatology of the atmosphere and the ocean. Habitat information describing environmental effects on species vital rates to the degree and at scales that affect population dynamics needs to be developed to more accurately assess and effectively manage wild capture fisheries in the face of anthropogenic climate change. Habitat information required for forecasting a future in which novel habitat conditions are likely to emerge, needs to be developed using approaches that move beyond statistical analysis of coarse scale species-environmental correlations that can be gleaned from stock assessment survey data. Approaches that combine field surveys stratified on the basis of ocean habitat features suspected to directly affect species vital rates underling population growth, with mechanistic experiments that can more precisely parameterize environmental effects on species vital rates are required. The mechanistic biological models that result can then be coupled with regional scale ocean models that capture the processes and properties of the water column as well as the seabed. Projections of habitat suitability made using with coupled models will allow us to better understand and represent habitat effects on species distributions and demographic rates at space-time scales useful for the assessment and management of marine ecosystems.