PhD Dissertation
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Title: Conserving Biodiversity in the Western Antarctic Peninsula Region: Marine Protected Area Design and Policy Implications

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ABSTRACT

Well-designed marine protected areas (MPAs) help preserve biodiversity and contribute to the management of sustainable fisheries. MPAs may be particularly important in environments where sea ice loss is rapidly increasing areas available to fisheries. The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has recognized that establishing MPAs could help achieve its conservation and fisheries management goals. CCAMLR has agreed on objectives to be met by future MPAs. Two of these objectives relate to preserving ecosystem processes and functions. Antarctic MPA design processes to date have relied on static maps of biodiversity values and human use patterns to inform boundary selection. Such processes assume spatial stability of the ecosystem functions and processes that created observed patterns of distribution and abundance. This work seeks to supplement the CCAMLR MPA planning process by using dynamic food web modeling to inform MPA boundary selection. Ecopath with Ecosim is a multi-tiered dynamic food web modeling software package. It was used to develop a mass balanced food web model (Ecopath), time dynamic simulations of the food web (Ecosim), and spatially and temporally dynamic simulations (Ecospace) for the Western Antarctic Peninsula (WAP) region. Ecospace simulations were used to evaluate the impact of four MPA boundary scenarios on biomass accumulation patterns. These analyses effectively tested if the proposed boundaries would protect ecosystem processes that contribute to biomass accumulation. The Ecopath model was designed to include all currently

monitored species as single species groups to facilitate MPA planning. The model was successfully calibrated for the years 1996-2012 using time dynamic simulations. When sea ice temporal dynamics were included as forcing functions, the model recreated trends in abundance for key monitored species. Ecospace simulations included spatial aspects of the sea ice regime and adequately represented spatial trends in biomass accumulation for the years 1996-2012. 100 year scenarios were developed that examined the impact of sea ice conditions, fishing levels, and MPA boundary configurations. Scenario testing illustrated the importance of fishing level in influencing spatial patterns of biomass accumulation. While MPA scenario testing failed to identify a strong candidate boundary configuration, it highlighted that to be effective in the WAP an MPA must be very large, be in place for an extended period, and should consider including southern regions that may have increased importance as sea ice loss progresses. The aim of this research is to use insights gained from spatio-temporal dynamic food web modeling to contribute to the discussion on which areas to prioritize for protection in the Western Antarctic Peninsula Region