ECOSYSTEM MODELING FOR THE CALIFORNIA CURRENT INTEGRATED ECOSYSTEM ASSESSMENT

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EXTENDED ABSTRACT

Marine ecosystem assessment is an ambitious goal that requires tools to synthesize a broad range of information related to ecological, fishery, and economic factors. Contributors to the California Current Integrated Ecosystem Assessment (Levin et al. 2009; Levin and Schwing 2011) have applied a range of statistical and simulation approaches, including qualitative modeling, time series analysis, food web models, and end-to-end ecosystem models. End-to-end ecosystem models are one type of tool that allows strategic planning, evaluation of management actions, and risk assessment (Plagányi 2007; Rose et al. 2010; Fulton et al. 2011).

At the CalCOFI conference I discussed the role of a spatially explicit Atlantis end-to-end simulation model. A brief overview of the Atlantis code base is available at http://atlantis.cmar.csiro.au/ and in Fulton et al. 2011; and an overview of the California Current application is available at http://www.nwfsc.noaa.gov/publications/documents/atlantis_ecosystem_model.pdf as well as in recent publications (Horne et al. 2010; Kaplan et al. 2011). I then presented two case studies, and a recent report made to the Pacific Fishery Management Council that included results from Atlantis and other Integrated Ecosystem Assessment tools.

The first case study (published as Kaplan et al. 2012) quantified the effects on ecosystem health that can be attributed to individual fishing fleets and gears, and their interactions. In the context of ecosystem-based fisheries management, the goal was to consider the indirect and cumulative effects of fishing, in addition to estimating direct fishing mortality. Simulations testing the effects of single fleets suggested that three groundfish gears primarily had direct impacts on harvested species, while effects from the pelagic purse seine fleet extended through predator-prey links to other parts of the food web. Our simulations identified six fleets that caused the bulk of negative impacts on a set of ecosystem health metrics. Specific fleets impacted different aspects of ecosystem health, but most effects were simply additive—the combined effect of two fleets was simply the sum of the individual fleets' effects. The analyses offer one way to sharpen the focus of ecosystem-based fisheries management in the California Current, emphasizing impacts and interactions of particular stressors.

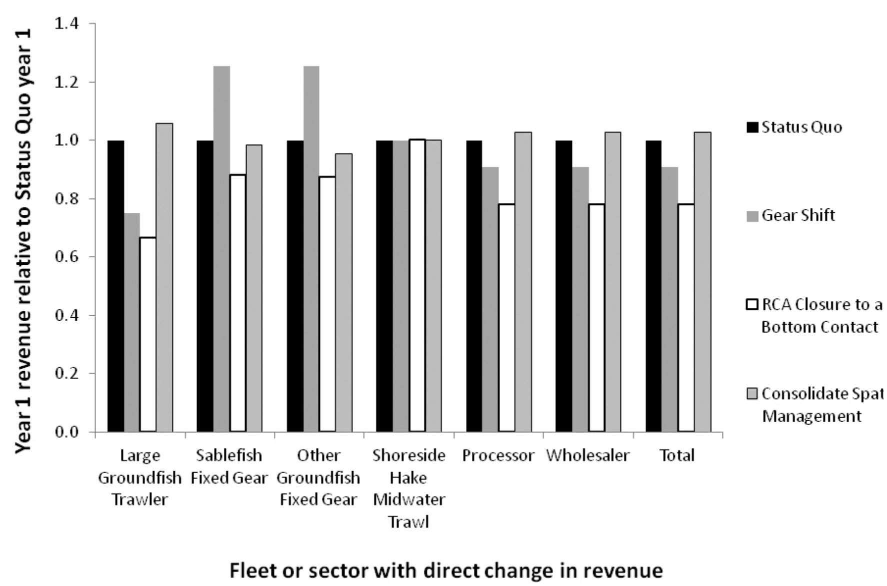

Figure 1. Revenue of seafood sectors for a set of four management scenarios, relative to a status quo scenario.

The second case study (published as Kaplan and Leonard 2012) combined the Atlantis ecosystem model with an economic model (IO-PAC) (Leonard and Watson 2011) to trace how changes in fishery management and seafood landings impact the broader economy. The potential effects of broad fisheries management options were explored, including status quo management, switching effort from trawl to other gears, and spatial management scenarios. Relative to the status quo, the other scenarios here involved short-term ex-vessel revenue losses, primarily to the bottom trawl fleet (fig. 1). Other fleets, particularly the fixed gear fleet that uses pots and demersal longlines, gained revenue in some scenarios. Income impacts on the broader economy mirrored the revenue trends. The long-term forecast (15 years) from the Atlantis ecosystem model predicted substantial stock rebuilding, increases in fleet catch, and roughly a 25% increase in income and jobs that derive directly and indirectly from fisheries. Linking the ecological and economic models allowed evaluation of fishery management policies using multiple criteria, and comparison of potential economic and conservation trade-offs that stem from management actions.

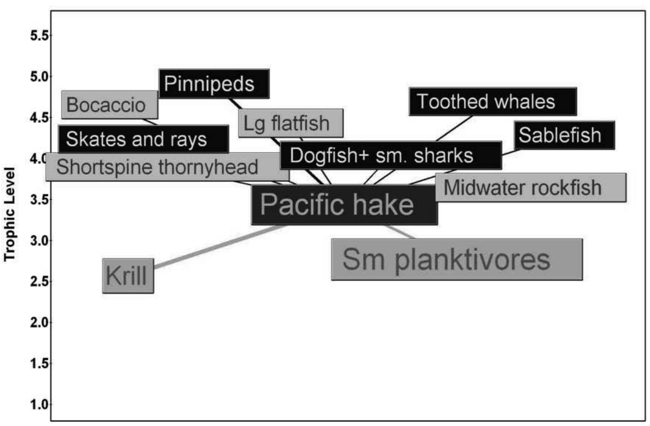

Figure 2. Primary food web of adult Pacific hake, *Merluccius productus*. Taken from http://www.pcouncil.org/wp-content/uploads/H1b_ATT1_DD_CA_ECO_NOV2011BB.pdf. Major prey items of Pacific hake are krill and small planktivores, and other light-colored boxes are both prey and predators of hake. Dark-colored boxes are major predators of hake. Position in the y-direction is approximately related to trophic level. Size of the box is related to biomass of the group. Links between boxes represent links in the food web; most diet information depicted here involves adult predators. The diagrams exclude minor prey items and predators that inflict small proportions of predation mortality on the focal group. Food web visualization software (Ecoviz 2.3.6) was provided by Dr. Kerim Aydin, NOAA AFSC.

Finally, at the CalCOFI conference I discussed ongoing ecosystem modeling efforts and needs within the Integrated Ecosystem Assessment. These efforts include improved modeling of fleet dynamics for the groundfish fleets, simulating climate change and ocean acidification, and the desire to extend the geography of the Atlantis model south of Point Conception. I also discussed one recent presentation of ecosystem information to the Pacific Fishery Management Council, using Atlantis and other tools to highlight climate and trophic effects on harvested species (fig. 2). Such efforts are a key part of the Integrated Ecosystem Assessment, and seek to distill results from several tools into forms relevant to decisions for managed species.

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