Part II

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ECOLOGICAL INTERACTIONS USEFUL FOR MARINE ECOSYSTEM-BASED MANAGEMENT: THE ROLE OF POSITIVE SPECIES INTERACTIONS, ECOSYSTEM ENGINEERS, AND SPECIES DIVERSITY

Many fisheries in the United States and worldwide are in decline (Jackson et al. 2001; Rosenberg et al. 2006; Myers et al. 2007), spurring the U.S. Congress (Ecosystem Principles Advisory Council 1999), the Pew Oceans Commission (2003), and the U.S. Commission on Ocean Policy (2004) to recommend that ecosystem-based approaches be incorporated into fisheries management. In theory, these approaches will take into account interactions between target species, non-target species (including humans), and their environment. However, because they represent a fundamental shift away from the single-species management approaches that have traditionally been the mainstay of natural resource managers (Ricker 1954; Beverton and Holt 1957; Pella and Tomlinson 1969), are difficult to define (Larkin 1996), and will likely require additional data, these new ecosystem-based strategies have proven difficult to implement. Furthermore, changes in the physical environment are likely to have profound effects on species composition, interactions, productivity, and ecosystem processes (Hunter et al. 1988; Francis and Hare 1994), and these changes will need to be considered as managers formulate ecosystem-based approaches to fisheries management.

Recent advances in marine ecology and in modeling trophic interactions have led to new perspectives on marine community and ecosystem processes which can be incorporated into ecosystem-based management. For example, the presentations at CalCOFI's 2006 symposium highlighted aspects of marine systems, including species interactions, facilitation, and biodiversity, which have ramifications for ecosystem-based management. Two of the symposium presentations, Steven Palumbi's talk on "The ecosystem function of marine biodiversity," and Fiorenza Micheli's discussion of "Marine ecosystem-based management: theory and practice," were not submitted for publication, but we encourage readers to examine their related recent papers (e.g., Mumby et al. 2006; Worm et al. 2006).

Traditional approaches to fisheries management consider only species which are targeted for fishing and typically do not include interactions between target species and other organisms in the marine environment. In her contribution, Baskett (2007) examined both multispecies fisheries models and marine reserve models to examine the effects of incorporating species interactions on yields, fishing rates, and marine reserve size. She included a model which incorporated a positive interaction—the effect of red algae on spiny lobster recruitment—and examined the ways in which facilitation affects model outcomes.

Bracken et al. (2007) also considered the beneficial effects of habitat-forming species on fisheries stocks. Using data from groundfish test fisheries, they found that fish catches were higher where habitat-forming deep-water corals were present. Bracken et al. used the same dataset to evaluate the relationship between the diversity of fish caught and the abundance of both target (sablefish) and total fish caught. Based on these analyses, and a meta-analysis of the effects of foundation species in a variety of marine ecosystems, they propose ways in which species diversity and the presence of foundation species can be incorporated into fisheries management strategies.

Negative interactions between commercially harvested species also occur, and models that incorporate these interactions are usually consistent with lower yields of one or more species. For example, Emmett and Sampson (2007) used a trophic model to simulate interactions between Pacific hake, juvenile salmon, and forage fish. They found that multiple factors, including species interactions, river flows, and sea-surface temperatures, explained annual variation in marine survival of salmon. Their work highlights the necessity of incorporating both physical and biological variables into management strategies.

Finally, Ruzicka et al. (2007) examined trophic interactions in the Oregon upwelling system using trawl surveys and the Ecopath modeling framework. They found that large jellyfish are the major consumers of zooplankton during the late summer, diverting zooplankton production away from higher trophic levels. This research suggests that jellyfish and other non-target species can play dominant roles in mediating ecosystem functions and, ultimately, fisheries productivity.

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