Ecosystem Considerations for 2006 in fishery management – Upper trophic level and aggregate indicators for the status of the southeastern Bering Sea

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Ecosystem Considerations for 2006 is an appendix of the Stock Assessment and Fishery Evaluations (SAFE) report, produced annually by the Alaska Fishery Science Center (AFSC) for the North Pacific Fishery Management Council (NPFMC). The appendix includes three sections: (1) an ecosystem assessment, (2) updated status and trend indices, and (3) ecosystem-based management indices and information for the Bering Sea (BS), Aleutian Islands (AI) and the Gulf of Alaska (GOA) ecosystems.

The purpose of the first section, Ecosystem Assessment, is to summarize historical climate and fishing effects from an ecosystem perspective and to provide an assessment of the possible future effects of climate and fishing on ecosystem structure and function. The purpose of the second section, Ecosystem Status Indicators, is to supply new information and updates on the status and trends of ecosystem components to stock assessment scientists, fishery managers, and the public. The goals are to give stronger links between ecosystem research and fishery management, and to spur new understanding of the connections between ecosystem components by bringing together many diverse research efforts into one document. The purpose of the third section, Ecosystem-based Management Indices and Information, is to provide either early signals of direct human effects on ecosystem components that might warrant management intervention, or to provide evidence of the efficacy of previous management actions.

Previous ecosystem analyses for the draft groundfish Fishery Management Plan environmental impact statements categorized effects into three main classes: predator–prey, energy flow and removal, and diversity. The Ecosystem Assessment section of the *Ecosystem Considerations* appendix adapts these as the three main objectives for ecosystem protection. Livingston *et al.* (2005) outline several topics within each of these objectives (Table 6). Several indices were chosen from the second and third sections of the appendix to address these objectives and topics. Trends in upper trophic level species/groups and aggregate indicators for the Bering Sea were reviewed.

No significant adverse impacts of fishing on the ecosystem relating to predator–prey interactions, energy flow/removal, or diversity were noted. There are gaps in understanding the system-level impacts of fishing and spatial/temporal effects of fishing on community structure and prey availability. Fishing mortalities from a multispecies bycatch model can be used to drive multispecies and ecosystem predator–prey simulations to evaluate the predator–prey implications of these fishing strategies. Predictions from multispecies models will be incorporated into the ecosystem assessment in future drafts when bycatch data can be updated and when some methodological problems are solved. Validation of models, research and models focused on understanding spatial processes, and improvements in monitoring systems would further our current understanding. Until more accurate predictions of climate status and effects can be made, a range of possible climate scenarios and plausible effects on recruitment should be entertained.

Reference

Livingston, P.A., Aydin, K., Boldt, J., Ianelli, J. and Jurado-Molina, J. 2005. A framework for ecosystem impacts assessment using an indicator approach. *ICES J. Mar. Sci.* **62**: 592–597.

Table 6 Significance thresholds for fishery induced effects on ecosystem attributes.

Issue	Effect	Significance Threshold	Indicator
Predator–prey relationships	Pelagic forage availability	Fishery induced changes outside the natural level of abundance or variability for a prey species relative to predator demands	• Population trends in pelagic forage biomass (quantitative - pollock, Atka mackerel, catch/bycatch trends of forage species, squid and herring)
	Spatial and temporal concentration of fishery impact on forage	Fishery concentration levels high enough to impair the long term viability of ecologically important, non-resource species such as marine mammals and birds	• Degree of spatial/temporal concentration of fishery on pollock, Atka mackerel, herring, squid and forage species (qualitative)
	Removal of top predators	Catch levels high enough to cause the biomass of one or more top level predator species to fall below minimum biologically acceptable limits	• Trophic level of the catch, • Sensitive top predator bycatch levels (quantitative: sharks, birds; qualitative: pinnipeds), • Population status of top predator species (whales, pinnipeds, seabirds) relative to minimum biologically acceptable limits
	Introduction of non-native species	Fishery vessel ballast water and hull fouling organism exchange levels high enough to cause viable introduction of one or more non-native species, invasive species	• Total catch levels
Energy flow and balance	Energy re-direction	Long-term changes in system biomass, respiration, production or energy cycling that are outside the range of natural variability due to fishery discarding and offal production practices	• Trends in discard and offal production levels (quantitative for discards), • Scavenger population trends relative to discard and offal production levels (qualitative), • Bottom gear effort (qualitative measure of unobserved gear mortality particularly on bottom organisms)
	Energy removal	Long-term changes in system-level biomass, respiration, production or energy cycling that are outside the range of natural variability due to fishery removals of energy	• Trends in total retained catch levels (quantitative)
Diversity	Species diversity	Catch removals high enough to cause the biomass of one or more species (target, nontarget) to fall below or to be kept from recovering from levels below minimum biologically acceptable limits	• Population levels of target, nontarget species relative to MSST or ESA listing thresholds, linked to fishing removals (qualitative), • Bycatch amounts of sensitive (low potential population turnover rates) species that lack population estimates (quantitative: sharks, birds, HAPC biota), • Number of ESA listed marine species, • Area closures

Table 6 Continued

Issue	Effect	Significance Threshold	Indicator
Diversity	Functional (trophic, structural habitat) diversity	Catch removals high enough to cause a change in functional diversity outside the range of natural variability observed for the system	• Guild diversity or size diversity changes linked to fishing removals (qualitative), • Bottom gear effort (measure of benthic guild disturbance) • HAPC biota bycatch
	Genetic diversity	Catch removals high enough to cause a loss or change in one or more genetic components of a stock that would cause the stock biomass to fall below minimum biologically acceptable limits	• Degree of fishing on spawning aggregations or larger fish (qualitative), • Older age group abundances of target groundfish stocks

MSST = minimum stock size thresholds; ESA = Endangered Species Act; HAPC = habitat of particular concern