Fisheries

Fisheries in an Ecosystem Context

1. Some Underlying Themes

* Inshore fish populations are affected by fisheries harvesting and land use activities in coastal watersheds (habitat loss/degradation, toxic pollution, eutrophication, etc.) and coupling with offshore physical, biological oceanographic processes (NAO, thermal gradients, offshore nursery grounds supporting inshore stock recruitment)-interaction with other working groups.

* Offshore fish populations are affected by fisheries harvesting and climate change interaction with climate working group on potential impacts of climate change on the lower levels of the food web supporting fish.

* Focus on fisheries ecology, biodiversity, ecological integrity of ecosystem and associated socioeconomic concerns.

* Potential clients for fisheries indicator working group output: EPA Coastal Condition Report, Gulf of Maine Council (GOMC) State of the Gulf Report; state/federal fisheries agencies.

* Dr. Spencer Apollonio's book on "Hierarchical Perspectives on Marine Complexities: Searching for Systems in the Gulf of Maine", which discusses ecological hierarchy theory and emergent properties of specific spatial/temporal scales of the physical environment in relation to the associated biotic components (plankton, nekton, marine mammals/seabirds). Similar ideas on the characteristic spatial/temporal scale of physical forcing factors and biota have been put forward by Drs. John Steele and Jurgen Sundermann (2003).

* Consider other living marine resources (LMRs) in addition to target and non-target fish populations: marine mammals, seabirds, other nekton?

* Ecosystem context includes essential fish habitat (EFH), predator/prey interactions, biodiversity, status of stocks (based upon biological characteristics), physical/chemical hydrographic characteristics, etc.

2. Key Questions and Indicators

* What is the status of fish stocks?
* What is the impact of fish harvesting on non-target species?
* What is the impact of gear types on habitats and species?
* What are the socioeconomic drivers in fisheries?

(a) Abundance and Distribution

* Fisheries-Independent Surveys (bottom trawls for demersal species, hydroacoustic surveys or midwater trawls for pelagic species, and beach seines for estuarine species) provide indices of relative abundance for target and some non-target species which can be used in stock assessments to provide estimates of absolute abundance; provides information on spatial/ temporal distribution which can be displayed as maps and analyzed by geographic information systems (GIS) to show changes over time, or multivariate statistical tools to derive other indicators. (See Link et al. (2002) for an example of deriving ecosystem-based fisheries management reference points/control rules; Bremner et al. (2003) for an example of using benthic macrofauna biological traits analysis for examining fishing impacts).

* Fisheries-Dependent Data on landings and locale: catch per unit effort (CPUE) can provide an estimate of abundance for target species; onboard observers can get information on bycatch of marine mammals, sea turtles, non-target fish species and possibly seabirds depending upon the gear deployed. For example, based upon bycatch in relationship to marine mammal abundance (OSP), U.S. federal fisheries are categorized into levels 1 (high), 2, or 3 (infrequent) to assess impacts on strategic marine mammal stocks; vessel monitoring systems (VMS) on some commercial fishing vessels provide information on fishing locations.

* Biological sampling through fishery-independent and dependent surveys (observers or port sampling) can provide information on age and growth, life stage and maturation status, and other data on the condition (weight/length ratio $K=W/L^3$; liver/somatic index = ratio of liver weight to total weight, or RNA:DNA ratio as growth indicators; gonadosomatic index = ratio of gonad weight to total weight for fish; the scope for growth can be used as an indicator for filter feeding mollusks) of fish species: size-at-age distribution and proportion of population in different age classes can be used as an index of overfishing. Rochet and Trenkel (2003) discuss a range of community indicators along a gradient from single species management to multispecies approaches and suggest using indicators, such as mean length and weight in community and proportion of noncommercial species in catch.

(b) Food Web Impacts -analysis of fish stomachs provides information on predator/prey interactions and their temporal/spatial changes: this data is used to estimate natural mortality in stock assessments and describe open water EFH in fisheries management. Even though ecosystem health is difficult to define operationally, researchers have defined indices for biodiversity (species richness and evenness) and biotic integrity (Linda Deegan's Estuarine Biotic Integrity Index) which could be used to evaluate food web impacts (See discussion in Rochet and Trenkel on why population-based indices are more useful in single species fisheries management.). Issues to be resolved include choosing the baseline for comparison for biodiversity and integrity indices and linking causes to perceived changes.

(c) Essential Fish Habitat (EFH) is often based upon benthic habitats defined by relative abundance of species in bottom trawl surveys or multibeam maps of geological bottom types plus key descriptive information on key water column parameters (depth, salinity,

temperature, and dissolved oxygen). There is a lack of quantitative understanding of the functional value of different EFH (levels 3 and 4 in NMFS classification) and fisheries scientists use our qualitative understanding (NMFS levels 1 and 2) to define EFH in federal jurisdictional waters (3-200 miles). EFH data is used to define habitat areas of particular concern (HAPC) to allow for special protection, and by fisheries agencies to comment on the potential impact of non-fishing, anthropogenic activities (dredge spoil disposal, oil/gas development, gravel mining, wind farms, pipelines, etc.).

Areas such as "no take" marine reserves provide descriptive information on impacts of fishing gear on EFH and non-target LMRs. The challenge is to convert this descriptive information into useful indicators. For example, Marine Protected Area (MPA) indicators include: size-at-age distribution of fish within, fish biomass within, fish biodiversity within, epibenthic biomass and biodiversity within, and export of larvae and juveniles/adults to external ecosystem. If one uses biodiversity, it is necessary to operationally define the biotic components of interest to managers: seabirds, sea turtles, marine mammals, nekton, macrobenthic epifauna and infauna, etc., since the biodiversity of the water column is dominated by the microbial loop and of the sediments by the meiofauna and microfauna which are poorly understood.

In estuaries, submerged aquatic vegetation (SAV), wetlands, mud flats, and sandy bottoms provide EFH for specific fish species. For example, the linkage between bay scallops and eelgrass beds could be used to develop an index between the mapped loss of eelgrass and the declines in bay scallop harvests. Unfortunately most finfish are habitat generalists, so that this approach is not applicable. There are certain guilds of fish that co-occur, such as sea robins which are ambush predators for juvenile cod and haddock near net snag areas that one can potentially map. There is a need for more research on the functional value of habitat. Identifying research priorities linking specific LMRs to the functional value of EFH and top priority habitats for multibeam surveys could be a useful approach.

(d) Socioeconomic Indicators: direction will depend on economists participating in working group. Fisheries management agencies collect data on the characteristics of the fishing fleet, landings, changes in coastal fishing communities, etc. which can be converted into indices of effort, direct and indirect value (ex-vessel cost/return, tonnage) of commercial and recreational landings, level of participation of commercial and recreational fishers in harvesting different species, level of other local and regional income generated from fishing, etc. Since fisheries agencies manage fishermen/women (fishers) and not fish, there is a need to convert this socioeconomic data into useful information by identifying appropriate indices of socioeconomic behavior.

There is much less information available on the natural capital value of fish stocks as a natural trust resource managed by federal/state fisheries agencies and the impacts of fishing and other anthropogenic activities on this natural capital. Dr. Steve Edwards (NMFS/NEFSC) has conducted some research on the natural capital aspects of sea scallop stocks and the sustainable development literature discusses approaches linking economic activities to their ecological consequences. (See Parris and Kates, 2003). Some appropriate

indices for natural capital values are needed that could be used in cost/benefit analysis to assess the impacts of anthropogenic activities on LMRs. Tools are needed to evaluate the efficacy of moving from single species to EbM (ecosystem-based management) approaches. There will be tradeoffs between costs of monitoring/ analysis and the approaches (tactical versus strategic) for harvesting and natural resource trust responsibilities at different points along this gradient. The increased complexities of multispecies management approaches require better visualization tools to aid decision-makers (Collie et al., 2003).

3. The fisheries working group agenda will be based upon: interests and expertise of participants; fisheries-related topics discussed in aquatic habitat, climate change, eutrophication, and toxic contaminants working groups; concept paper which discussed the four potential questions of interest suggested by the Steering Committee; web-based survey for workshop; and feedback from Steering Committee members who brief their senior policy makers on issues which should addressed in the fisheries working group.

The working group participants will need to decide the proper balance between ecosystems-based fisheries management (harvesting, multispecies interactions, impacts on essential fish habitat, effects of bycatch on nontarget species, etc.) and examining fisheries in an ecosystem context (climate change, nutrients, toxics, land use change, stochastic environmental change, and fisheries harvesting impacts on food webs). Given the broad range of potential clients for the output from the fisheries working group, we will need to prioritize our discussion to those useful to managers/senior policy makers. The overall goal is to identify indicators which can link monitoring/data gathering efforts to information needs required to manage fisheries in a more holistic context than the current single species approaches. The working group will develop recommendations for consideration by the Senior Managers Panel and other working groups and hopefully receive some constructive feedback.

4. References.

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