AFS POLICY STATEMENT #5:

CUMULATIVE EFFECTS OF SMALL MODIFICATION'S TO HABITAT

Introduction

Accumulation of localized or small impacts result in regional and global changes in fisheries. These accumulations of effects, often from unrelated human actions, pose a serious threat to fisheries. More progress is needed at analyzing, mitigating and designing management actions which achieve fisheries objectives in an environment of complex change. Ongoing debate and discussions have been devoted to the subject of cumulative effects demonstrated little consistency among federal agencies in the United States in assessing cumulative effects to fisheries.

Future coordination of the many levels of skill within the American Fisheries Society are a key ingredient to progress against undesirable impacts to fisheries. Study of potential cumulative impacts from small modifications ranges from global to that space occupied by an individual animal. Scientists must deal with global ecology and toxicity to individual animals simultaneously.

Issue Definition

Cumulative effects are defined as, environmental change resulting from the accumulation and interaction of the effects of one action with the effects of one or more other actions occurring on a common resource. Effects can be additive and interactive in a variety of ways. Complex spatial and temporal relationships exist. These are frequently simplified as indices or other estimates.

The problem of scale is a major area needing attention. Fish habitat consists of a wide array of physical, chemical and biological conditions within which fish live. A habitat modification can be perceived to be small merely by increasing the geographic area, or length of time, or the array of habitat elements, within which the modification is described.

For the sake of brevity, this paper discusses modifications of fish habitat along a geographic spectrum, as opposed to a temporal spectrum or activity related spectrum. A geographic spectrum ranges from global to local or site specific. A temporal spectrum would range from instantaneous to long term. An activity spectrum would range from a single act to multiple complex actions. All accumulation of effects contain elements within all three spectra. “Modifications of habitat" refers to those changes in habitat brought about by post-Industrial Revolution civilization. Other ecological processes, to which fish have adapted for several thousand years, are considered to be natural.

Impacts on Aquatic Environments and Effects on Fisheries Resources

Global

World-wide declines in fish abundance have been documented for species which have been historically of major economic and social significance. Time trends resulting from multiple effects on salmon populations have resulted in declines over much of the globe. Pollution and physical side effects, such as mineral extraction and power plants, can have an overall negative effect on fisheries productivity. Such effects are of international concern.

Oceanic, Regional and Watershed

A snapshot of potential ramifications of small habitat modifications on a global basis is seen by aggregating from habitat elements to watersheds, then to regions and oceanic areas. International concern is raised due to changes in oceans. Potential effects of small man-caused temperature changes can result in oceanic change and loss of fishing capacity, as well as threats to aquaculture.

Regional trends have also been noted which cause concern for fisheries. Recently widespread increases in nitrate, chloride, arsenic and cadmium in rivers of the United States have been related to man's activities. These trends are the result of apparently unrelated actions.

Regional differences in acidity of lakes in the United States have been documented, but the area affected is generally less than 10% of any lake region. It is estimated that acidification in the Adirondacks of New York State resulted in a loss of $1-3 million in recreational fishing.

Effects to habitat for individual classes or groups of animals also occur on a regional basis. Trout density is projected to decrease over a fifty year period due to increased acreage in human use and decreased old-age hardwood acreage.

A textbook example of regional effects to fisheries from a small habitat modification occurred in the Great Lakes. Alteration of fish passage in a relatively small area resulted in invasion of the lamprey and subsequent declines occurred in valuable lake trout fisheries.

Wetlands losses do not conform to strict regional or watershed delineations. Alteration occurs from multiple actions including, urban development, pond development, agriculture and channelization.

From 1981-1985, in the Southeastern United States multiple projects potentially affected over 180,000 acres. Estuaries of the Northern Gulf of Mexico are affected by channelization, draining, and bulkhead, dam and reservoir construction, minerals

production and power production. Similar modifications of Maryland's Coastal Zone have occurred.

Cumulative change can occur in more easily defined ecosystems such as watersheds. Effects within smaller watershed areas fall within many categories from sedimentation to dredging and organic debris distribution. Hydrologic effects and sedimentation from land disturbance are inter-related. Biological ramifications are dependent on watershed size, because there can be linear increase in fish species as stream order increases and there are numerous strong relationships among biological measures and stream size.

Case history studies of cumulative effects point to habitat losses in many watersheds from the lower Klamath River Basin, and the Flathead Lake basin to the San Joaquin River. These and similar studies demonstrate that small amounts of change in habitat and subsequent fish population loss of only about 20% would result in substantial economic loss of up to $2 million per drainage.

Within watersheds, hydropower development can have cumulative effects. Ecological effects vary-with flow fluctuations and channel morphology. It has been concluded that highly variable flows affect fish differently depending on the way they use habitat, but that flow fluctuations reduced community complexity. These change's are not always predictable, nor can factors such as mortality, be apportioned to sources.

Effects within watersheds can accumulate in large drainage basins. Decline of salmon and steelhead populations in the Columbia River resulted from cumulative effects including construction of hydropower facilities. Cumulative losses at nine dams amounted to about 90% of the downstream migrants, but that each dam only contributed from 4 to 20% loss.

Within watersheds a fish species may or may not respond to habitat factors as described by laboratory experiments. Brook trout numbers in a Black Hills stream were poor indicators of temperature and turbidity, but-reflected changes due to physical alterations of habitat. Such response of fish populations makes quantitative prediction due to small habitat modifications difficult. Gains resulting from planned mitigation or improvement projects cannot always be quantified for similar reasons.

Cumulative improvements to fish habitat may occur, but documentation is scanty. Effectiveness of fish habitat improvement projects needs to be determined based on at least a river basin evaluation of gains. Mary studies to date document increased trout standing crop in improved stream segments or associated with a few placed structures.

Cumulative losses of even one element of fish habitat can extend over long time periods. Losses of habitat elements such as large woody debris can have effects for 80 to 160 years.

An examination of how effects can accumulate from waterheads to regional areas, then oceans and then the globe, is incomplete without first integrating how fish respond to

their immediate surroundings. These immediate surroundings form the building blocks, from which larger habitat elements are composed.

Surroundings of Individual Fish

Fish react to their habitat in a variety of ways, including changes in ecology and behavior, growth and reproduction, homeostasis, organ function, histology, cell integrity and gene function . Extremely small amounts of toxicants in the habitat on a per volume basis can have significant effects. Many effects can be sublethal, but result in lost production.

Cumulative effects occur by altering growth, reproduction and tissue. Growth inhibition in catfish from cumulative effects of recycled water, bioaccumulation and reproductive effects of selenium, persistent histological changes after cumulative loading of ammonia and growth reductions in salmon when they were exposed to chronic turbidity, are all examples.

Cumulative effects can alter behavior. Temperature patterns over the prespawning and spawning period affected the number and fecundity of the successive batches of tench and cumulative fecundity during the season. Cumulative changes in temperature affect microhabitat selection by fish. Cumulative arsenic trioxide levels decreased the migration success of salmon.

Trophic level can determine the nature of cumulative effects. The type of habitat can effect chemical accumulation and fish can internally alter elements provided by the habitat.

Effects to individual animals often allow interpretation of the effects of habitat alteration in larger contexts. It has been illustrated that the influence of global fallout on bottom sediment by modeling the accumulation of ^{137}Cs in carp. Increasing trends in some toxics on a regional level can only be viewed as a threat to fisheries based on existing knowledge.

Summary

Cumulative effects of small habitat modifications cannot be simply and easily written into a precise linear equation, due to mathematical limitations. Even without the application of quantitative techniques, certain conclusions can be drawn.

All individual effects to fish habitat result in cumulative effects to global fisheries. Individual effects include a bewildering array ranging from wetland losses and acidification, to bioaccumulation of toxins and watershed alterations. Effective application of the slogan, "think globally act locally", is necessary for progress on the issue of cumulative impacts of small habitat modifications.

It is unclear whether improvement efforts to some fish habitats result in cumulative increases in production or whether they mitigate other habitat alterations. Little effort in the literature is devoted to the cumulative effectiveness of fish habitat mitigation or improvement projects.

Needed Actions on the Part of the American Fisheries Society

Because of the potential magnitude of cumulative effects of small modifications to habitat, progress in research, assessment and management is required. The Society should take the following actions in order to make further progress on the issue of cumulative effects of small habitat modifications:

1. The Society will encourage full narration of potential cumulative impacts during project planning, in addition to utilizing linear analytical modeling, until more descriptive quantitative techniques are made available. In order to facilitate scientific progress, The Society will form an interdisciplinary committee to develop a common framework for assessment methodologies. Upon completion of the committee's task, regulatory agencies will be strongly encouraged utilize full and complete disclosure using new methodologies.

2. The Society will discourage actions which cause predicted small losses to fish habitat, unless a rigorous disclosure is made of effective mitigating measures which fully compensate for projected losses. Actions addressed will include wetland alteration, watershed modification, point source pollution and nonpoint source pollution.

3. The Society will encourage expanded research on the topic of habitat improvement and mitigation. New research should be focused on offsetting potential habitat loss and ecosystem restoration.

4. The Society will encourage development of more integrated approaches to research and professional communication. The Society will sponsor an international scientific symposium on cumulative effects.

5. The Society will develop and incorporate in its long term action plan and its visibility plan measures to more fully educate the public about cumulative effects. These measures will also be designed to encourage better incorporation of the study of cumulative effects in university fisheries programs.

6. The Society will encourage more experimental research at the watershed level. This is the largest practical scope for controlled and replicated study.